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AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

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E. A. AVERILL, }

MAY, 1908

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RELIABILITY OF THE INDIVIDUAL MOTOR DRIVE FOR MACHINE TOOLS.

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A comparatively large amount of silent chain is also used in this shop, especially in connection with the application of individual motor drives to the older machine tools, which were transferred from the old shops. This chain has been in operation for about five years with splendid results, except that on a wheel press and a punch and shear, where the work is intermittent, the chains had evidently not been properly selected. The one on the wheel press was removed and replaced by a pinion and gear, while the chain on the punch and shear was doubled in width. On some of the smaller drill presses the chains wore quite rapidly due to their not being of sufficient capacity. Except for these cases, which were due to an error in selecting the proper size chain, it has given very good results and is regarded as more satisfactory than the direct gear and pinion drive.

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The application of individual motors to the older tools was described in connection with a series of articles which were published in this journal during the years 1903 and 1904. A description of the locomotive repair shops at McKees Rocks was also published during these years.

BOILER EFFICIENCY

In his paper on the heat balances in locomotives, presented before the Institution of Mechanical Engineers of Great Britain, parts of which are given in this issue, Mr. Lawford H. Fry states that some recent tests on the Pennsylvania Railroad locomotive testing plant at Altoona show that the boiler efficiency is independent of the grate area and that it makes no difference whether the same total amount of coal per hour is burned on 55.5 sq. ft. of grate area, at 72 lbs. per sq. ft. per hour, or on 29.76 sq. ft. at 134 lbs. per sq. ft. per hour. These experiments were all made on the same locomotive and it is explained that the reason lies in the fact that the firebox volume, which was constant, is the controlling factor.

From this it would appear that in the case of a locomotive with large grate area, which did not properly cut its fire, the bushing of the nozzle might be avoided by simply bricking over a section of the grate, thus giving more draft through the fire without decreasing the efficiency of the boiler or the locomotive.

Mr. Fry also arrives at some other interesting conclusions from his study of the St. Louis and Altoona tests, one of which is that the efficiency of the absorption of the heat by a boiler is practically independent of the rates of combustion and evaporation and that under all conditions of working the heating surface will absorb about 80 per cent. of the heat produced by the combustion. This figure seems to be more or less independent of the design of the boiler and of the ratio of the heating surface to grate area. From this it will be seen that the efficiency of the boiler as a whole is mainly determined by the efficiency of the combustion, which in the same firebox falls rapidly as the total amount of coal burned per hour is increased.

BURNING LIGNITE COAL IN LOCOMOTIVES.

There are large deposits of lignite in the northeastern part of Wyoming; the southeastern part of Montana; the western portion of North Dakota, and the northwestern part of South Dakota. As may be seen from the analysis on the first page of this issue, this coal is very low in ash, although the amount of moisture is higher than that in the ordinary bituminous coal. It is free from slate and rock and burns easily, with no clinkering. It can be mined cheaply, but disintegrates quickly when exposed to the air, so that it must be used as soon as possible after being removed from the mine. The railroads in this northwestern district have made several attempts to burn this coal, because of the great expense of hauling bituminous coal from Iowa, Illinois, Missouri and the coal producing states in that district. If the lignite can be burned successfully it will not only greatly reduce the cost of locomotive fuel in this district, but will tend to develop the coal mining industry along the lines which pass through this territory.

While the lignite is used more or less for industrial purposes the fact that it disintegrates so quickly interferes with the mines operating and storing up coal during the time of year when the industrial requirements are low; if the railroads could use the coal it would keep the mines operating efficiently the year round. While all of the roads passing through the district have studied the matter of its use closely and have experimented with it more or less, only one road is using it extensively at the present time. The objection to its use in locomotives is in the fact that it is very light and the sparks which are carried out through the stack set fire to the surrounding country. The small particles of burning lignite which pass out hold the fire for a long time until they are entirely consumed. The climate in this district is particularly dry, so much so that it has been said that the trainmen must be very careful as to the language they use while passing through it in the dry season in order not to set it on fire. The Burlington Railroad has been experimenting with this fuel for a number of years and has finally perfected the grate and front end arrangements of its lignite burning engines, so that when the engines are evenly and properly fired, practically no sparks escape. However, under the average condition of firing, even with the best arrangements which have been worked out, some few sparks do escape. It would appear that this difficulty can be entirely relieved by the introduction of a successful spark arrester.

A number of the roads in the middle west are making a careful study of this question at present and it is quite probable that its final and complete solution is near at hand. The progress which has been made on the Burlington, which at present is burning about 3,000 tons of this fuel per day, is carefully traced in an article, by Mr. O. N. Terry, on "Lignite Burning in Locomotives" on page 161 of this issue.

NEW YORK SUBWAY CARS.

At the present time the New York subway car equipment consists of 500 composite cars, in which some wood is used, 300 all metal, strictly fireproof cars and 50 all metal cars, which have been recently delivered. The first 800 cars are practically the same size, with the same seat and door arrangement. The last 50 have wider doors and have only one bank of cross seats in the center of the car. There are 10 longitudinal seats on each side, instead of nine, making the seating capacity of the last 50 cars 48 instead of 52, as on the first cars.

The operation of these cars in subway service has disclosed certain fundamental defects in design which should be remedied before the subway can furnish the speed, comfort and capacity which the passenger has a right to expect. Mr. Bion J. Arnold recently submitted an extensive and very complete report upon the subway car to the Public Service Commission for the First District of the State of New York. His conclusions are that the present car when provided with an additional side door, located near each end, thus making four doors in each side of the car, will best meet the conditions of the present subway and that when these cars are properly operated through the stations as rapidly as the signal system, when modified as recommended in a previous report, will permit, a marked increase in the capacity and comfort of the subway will be realized. The following is a brief abstract of Mr. Arnold's report:

At each express station the passenger has the privilege of transferring from the local trains to the express trains, and vice versa, and to facilitate this transferring the five express stations are arranged with island platforms between the tracks, so that the passengers can leave the trains of one service, cross the platform, and directly enter the cars of the other service. This privilege is much used, and even abused to a great extent; owing to the excessive use of this transfer privilege many passengers, in traveling from their starting points to their destinations, are loaded and unloaded twice, and a large number of them three times, so that many of the passengers use the car doors four times, and some six times. On account of the excessive use of the doors the present type of car, which ordinarily gives satisfactory service, has proved to be entirely inadequate for the subway.

At the present time it is possible, except on very busy days, to get 30 trains an hour through the limiting stations on both the local and the express tracks. During rush hours the cars often carry twice as many passengers as there are seats and during the height of the rush periods there are times when three times as many passengers are carried on some express cars as there are seats, although the latter condition exists for only short periods of time on very busy days. Since the extension of the subway to Brooklyn the time table has called for 40 express trains per hour between 96th street and Brooklyn Bridge during the rush periods. The delays of the trains at the station platforms, however, have seriously interfered with the carrying out of this schedule, and although there are parts of the system where 40 trains per hour are supplied during certain periods of the day, this rate is not maintained at the critical part of the

rush hour period, the time when it is most needed. In other words, as soon as the demand for seats increases beyond a certain limit the supply of seats begins to decrease.

Analysis of Delays at Station Platforms.

The present arrangement of loading and unloading passengers, through the same end doors of the cars, is the chief cause for the inefficient operation during the rush hour period. An analysis of the average time required by express trains at a station platform during the height of the rush hours shows the following figures:

		Average, Seconds.
1.	To open doors of cars after train has stopped	2
2.	To unload an average of 163 passengers through 14 doors (15 to 50 seconds)	20
3.	To load an average of 206 passengers through 14 doors (15 to 30 seconds)	20
4.	To close the car doors and give the signal by means of bell rope to motorman	13
5.	Total average time of express trains at station platforms between stopping and starting during the height of the rush hours	55

Defects in Present Arrangement.

Apparently the only permanent way to improve these conditions is either to reduce or abandon the transfer privilege, or to change the car. While it may be contended that such convenient means of transferring at so many points should not have been provided, it is Mr. Arnold's opinion that this privilege, having been established, cannot now be withdrawn, and that the only remedy, therefore, is to change the cars.

The present car works very well during periods of light and fairly heavy travel, but as soon as it is called upon to carry upwards of 100 passengers the single end doors become a decided disadvantage and their inefficiency in handling large crowds seriously interferes with the prompt movement of trains. As the limit of capacity, under present circumstances, would be the maximum carrying capacity of the car, it is essential that a type of car be used in which this limit can be easily and quickly reached. To state the case briefly, the principle defect in the present car is due to the fact that a definite and ready circulation of traffic is not provided for and that owing to the lack of sufficient side doors, properly located, the maximum carrying capacity of the car cannot be easily and quickly reached.

In a study of the signal system it was found that trains could be run between stations on a headway of 90 seconds, or at the rate of 40 trains per hour. Because of delays at the station platforms and also on account of the arrangement of signals on the tracks approaching the stations it is just possible, under present conditions, to pass 30 trains an hour through the busiest stations during rush hours. If the present arrangement of signals is retained the only possible way to secure an increase in the capacity of the subway from 30 trains per hour to 40 trains per hour is to scrap, or use elsewhere, the entire subway car body equipment and build new cars at an expense of at least $5,000,000, and re-arrange the present platforms, which is practically prohibitive.

The most economical and efficient way, as well as the quickest, to secure a capacity of 40 trains per hour is to improve the signal system, as recommended in a previous report, and at the same time alter the present cars sufficiently to limit the platform waits to a maximum of 35 seconds. It should be understood that 35 seconds is the limit which if exceeded would at once affect the headway and that the average platform wait should, therefore, be less than this in order to provide for operating exigencies.

To secure this result it is evident that the loading and unloading must be carried on at the same time. Some improvements should also be expected from the use of the pneumatic door handling equipment and the electric door signal. These changes should bring the actual wait at the station platform down to the following figures:

		Seconds.
1.	To open doors after train stopped	2
2.	To unload 163 passengers through 14 doors, and to load 206 passengers through separate doors, both processes being carried on at the same time	20
3	To close doors and give signal to motorman	8
4.	Total *average* time of trains at express stations during rush hours should not exceed	30

It is plain that in order to run 40 trains per hour through the subway it is essential that more door openings be provided than are found in the present cars.

Requirements of a Successful Subway Car.

A successful car for the present subway should possess as many as possible of the following requirements:

1. Separate entrances and exits.
2. A space which can be cleared so as to be ready to quickly receive the passengers boarding a car.
3. Convenient means of circulation inside the car.
4. Standing-room space contiguous to the exits.
5. As many cross-seats as practicable.
6. Exit and entrance doors sufficiently removed from each other to allow for the car stopping convenient to guiding rails on the platforms.
7. Doors located so as to minimize the danger from open spaces at curve platforms.

The various cars may be classified in accordance with the number of doors in the sides of the cars as follows:

Cars with central side door and end doors.
Cars with two quarter side doors.
Cars with three doors near center.
Cars with multi side doors.
Cars with double doors near ends.

Each one of these types may have seats of either the longitudinal, the cross "back-to-back," or of the "walk-over" style, or a combination of two or more styles.

The advantages and disadvantages of each of the above type of cars are considered in Mr. Arnold's report and several seating arrangements are presented for each type.

Cars With Central Side Doors and End Doors.

After a thorough discussion of this type of car, Mr. Arnold comes to this conclusion: "The successful use of the central side door in terminal work does not furnish a precedent which demonstrates that this type of car would be satisfactory under subway conditions, whereas the failure of the center door on the Boston subway, to reduce the length of stop to much less than the time required in the New York subway, even with the present end doors, does not furnish any encouragement toward rebuilding the present subway cars so as to provide them with center doors." Although signs were posted in the Boston cars and the guards and station attendants were instructed to have the passengers enter the cars at the end doors and leave by the center doors, it was found that the passengers could not be controlled sufficiently to maintain this much desired circulation. This type of car is being used in the Hudson tunnels successfully, but the conditions are very different from those in the subway.

Following this is an extensive discussion of the various seating arrangements of this type of car. This is followed by a discussion of cars with multi side doors, such as used on the Illinois Central Railroad.

Multi Side Door Car.

To use the multi side door car would necessitate the scrapping of the car bodies of the present equipment and of changing the station platforms. To use these cars exclusively it is also necessary that the multi side doors be promptly closed by the guards. In Chicago there is apparently no difficulty in doing this, but the traffic in the subway during rush hours is fully ten times as much as that on the Illinois Central during the corresponding period. As experience in the subway has demonstrated that in order to close the car doors during the rush hour period a corps of uniformed, trained, platform guards, in addition to the train guard, is absolutely necessary, it is difficult to see how the car doors could be closed promptly, thus limiting the platform delays, unless the stream of passengers was stopped before it reached the loading platform. This would necessitate a radical re-arrangement of the present platforms.

If the multi side door car is to be considered for future subways, the station platforms should be arranged so that the un-

loading can be done upon one station platform and the loading can be accomplished from another and separate platform.

A number of different seating arrangements are discussed for multi side door cars for both the present and future subways.

The type of car recommended by Mr. Arnold for the present subway is then considered.

Cars With Double Doors Near Ends.

Without weakening the present car, or adding materially to its weight, it is possible to introduce additional side doors, one near each end of each side of the car and as near as practicable to the present end doors, the distance between the doors being at least sufficient to furnish a pocket for the sliding doors.

These additional doors can be added without disturbing the present seating arrangement of the car to any great extent. It is true that the introduction of these doors will make it necessary to remove 8 seats from each car, but the operation of the cars in actual service will make it possible to pass so many more cars through the subway that the loss of 8 seats in each car will be more than offset by the additional seats in the added cars, and the extra standing room, so convenient to the separate exit, is a feature which will decrease the station waits, and thereby increase the schedule speed.

This proposed change in the present car has many advantages which even a casual study will reveal. The new doors can be used for exits, and the present end doors for entrances, thus providing at once the means of carrying on the process of unloading and loading simultaneously and without the present conflict which during rush hours has become so objectionable.

This car provides a separate space for leaving passengers to collect around the exit doors without blocking the space which should be provided for the passengers entering the car. The result will be that passengers will move in and out much more quickly than at present, and the movement of passengers into the car will facilitate the movement of passengers out of the car.

With this car it would be possible to keep the platforms clear of standing passengers, particularly at the time of approaching a station where considerable additional load is to be expected. With the present cars it is impossible to keep the platform clear, as the passengers readily make the excuse that they are getting ready to leave the train at the next station. With a clear platform there should be none of the discomfort now experienced in boarding a crowded car; the passengers will pass rapidly into the empty car vestibule, and can move at once into the space which has been vacated by the leaving passengers.

There should be no hesitation on the part of a passenger in the selection of an entrance with this type of car, as is so often the case with the multi side-door car. Under these circumstances there is no reason why a rate of flow of passengers *in* and *out* of the car amounting to at least 5 passengers per car per second should not be expected with this car with double doors near the end, and this rate is fully as good as the experience in Chicago would lead us to expect from the multi side door cars, even with 8 doors distributed the entire length of the car.

While this type of car provides for setting up and maintaining a circulation, this circulation is not obtained at the expense of comfort to the through passengers, as the circulation is confined to the two ends of the car, and it is therefore not necessary for a passenger boarding a train at one station and getting off at another to pass through half the length of the car, with the attendant discomfort to both himself and to all of the other passengers in the car.

Both the exit and the entrance doors are directly under the eye of the guard, who is thus in a position to accentuate the circulation, and, therefore the rapidity of handling the passengers, by opening the exit door slightly in advance of the entrance door, which can easily be done by either mechanical or pneumatic means. This car lends itself readily to the introduction of platform railings at all of the more important station platforms.

The standing room in this car can be increased during rush hours by folding up the two seats between the doors, and, while this practice is not to be commended, there will be times, and particularly on heavy days, such as Mondays, when this feature could be utilized.

The present cars can be changed to conform to this arrangement for an expense of about $2,000 for each steel car, and about $1,500 for each composite car.

For the present subway this car seems to possess more advantages and fewer disadvantages, both from the standpoint of the public and the operating company, than any other type, and its use will increase the capacity of the subway sufficiently to fully justify the expense of altering the present cars into cars of this type.

More Compact Seats for Future Cars in Present Subway.

In the present subway cars the space devoted to the cross seats is used in an uneconomical manner. There are 70 inches between the center of the backs of these seats, which is taken up by two 6-inch back cushions, two 18-inch seats and a clear space between seats of 22 inches. Where space is as much at a premium as it is in the subway cars, the arrangement of these seats should be made more compact, and this can be done without sacrificing the comfort now secured with the more liberal spacing. For double side seats, served from a center aisle, a clear distance of 20 inches between seats is sufficient, and the allowance of 18 inches for each seat, together with its back, has been found satisfactory, thus making a total over-all distance of 56 inches for one bank of seats. The width of 18 inches for each passenger for the cross seats and of 19 inches for the longitudinal seats in the present car is good practice.

With the more economical arrangement of cross seats, more space can be devoted to such seats and at the same time the seating capacity of the car can be increased. This improvement should be kept in mind in ordering future cars for the present subway.

Recommendations.

The recommendations, summarized, are as follows:

First—That every car used in regular passenger service in the present subway be provided with two additional side doors, located near the ends.

This car is recommended for the following reasons:

1. The double-door space at each end of the car will greatly reduce the present station waits.
2. The separate exits and entrances will remove the present uncomfortable conflict at the car doors.
3. The present cars can be altered into this type of car without detracting from their structural strength, or materially altering the present seating arrangement.
4. The result in increased carrying capacity due to the changes will abundantly justify the investment.
5. This is the only type of car with additional doors that will not materially increase the present trouble due to curved platforms.

Second—That all cars be provided with either pneumatic or other means for quickly opening and closing the doors, and with signals which will automatically indicate to the motorman when the last door is closed.

Third—That all new cars be of metal and provided with seats more economically arranged.

Fourth—That when the cars of the double end-door type are put into service a system of platform railings be provided to direct the passengers.

Fifth—That for future subways a wider car should be considered. This car may be a multi side-door car, if separate platforms can be arranged for each class of trains, and if the stations can be designed to control the flow of passengers at the entrance to the platform instead of directly at the car doors. If, however, it is found that it is impracticable to design stations with sufficient room for waiting passengers independent of the station platforms, it will probably be found that the best car for future subways is a wide car of the type with double doors near ends.

Sixth—That if it is found that future subways cannot be built without the occasional use of curved platforms, the cars for these future subways should be designed so as to allow the station platforms to extend under the car in such a way that the necessity for sliding platforms will be obviated.

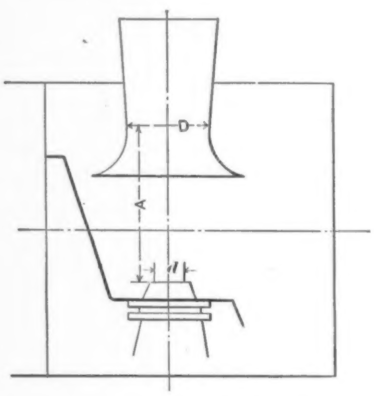
MORE ABOUT SMOKE STACKS.

TO THE EDITOR:

In the March number of your Journal, page 85, appeared an article on the subject of smokestacks by Mr. W. E. Johnston, which, while it was evidently the result of much thought, and gave results which would probably be successful in service, could never become popular with builders or users of locomotives to any extent on account of the great variation in stack diameter given for a small variation in the diameter of the exhaust nozzle. Thus for a 4½" nozzle, with a distance from nozzle to choke of 40", Mr. Johnston's diagram would give a stack diameter of 14". Now, suppose we found we could use a 5" nozzle and still have a free steamer, we find we should have equipped the engine with a 15½" stack.

The Master Mechanics' Committee of 1906 ignore the factor of nozzle diameter altogether, making the diameter of stack depend entirely upon the diameter of the smokebox, and the distance from nozzle to choke. While the factor of nozzle diameter undoubtedly should enter into the question, it is only in a slight degree that it affects the stack diameter.

This peculiarity in Mr. Johnston's deductions undoubtedly arose from his attempt to reconcile the recommendations of the three committees of the Master Mechanics' Association, those of 1896, 1903 and 1906, whereas those of 1906 alone are based upon



$$D = \left(d + \frac{A}{6}\right) 1.4. (1)$$

or

$$D = \left(\frac{c}{4} + \frac{A}{6}\right) 1.4. (2)$$

c = Diam. of cylinder.

FIG. 1.

a front end without draft pipes. The committees of 1896 and 1903 made the exhaust jet fill the stack, while the last committee leave a considerable space (shown by the shaded portion of the template, Fig. 2) around the jet for the entrainment of gases. It is for this reason that the stacks of the 1906 committee are larger than those previously used and any attempt to reconcile these results with those previously obtained with the use of draft pipes cannot give a rational progression.

For the purpose of obtaining the correct stack diameter in the drawing room I have found a template of the form shown in Fig. 2 to be very useful. This is made on celluloid or tracing cloth to the scale of the elevation drawing of the locomotive and its form is based solely upon the 1906 tests, except as they are varied slightly by taking the nozzle diameter into consideration. The taper of the exhaust jet (2 in 12) was determined by the 1896 tests, and has since been verified for the type of nozzle commonly used—that with sides tapering to from 1" to 3" of the top.

Mr. A. J. Pitkin, then general manager of the Schenectady Locomotive Works, made tests some years ago by painting the inside of various sizes of stacks and noting where the cinders removed the fresh paint. His results gave an angle of 9°, which is almost identical with a taper of 2" in 12". In fact, this form of the jet for the common type of nozzle has never been called in question. Therefore, we have but to start with the diameter of nozzle, add the height "A" divided by 6, see Fig. 1 (corresponding to a taper of 2 in 12), and multiply by 1.4, a constant giving the proper proportion of space around the jet as determined by the 1906 tests. This gives the first formula.

The second may be used where the size of nozzle is not known, and is based on the rough and ready rule that the nozzle diameter is about ¼ the diameter of the cylinder. This is not accurate enough for exhaust nozzles, but is sufficiently so for smokestacks.

To use the template, place the line giving the proper diameter of exhaust nozzle at the top of the nozzle, and read the diameter of stack from the line nearest the desired location of choke. The taper of stack should correspond with the taper of the jet.

Those who have attempted to use the Master Mechanics' formula for stack diameters, have often been "held up" on the start by the admonition to make "h"—the distance from center line of boiler to top of nozzle—"as great as possible." The question is, how great can it be made? This lower limit is obviously determined by the amount of area desired below the diaphragm

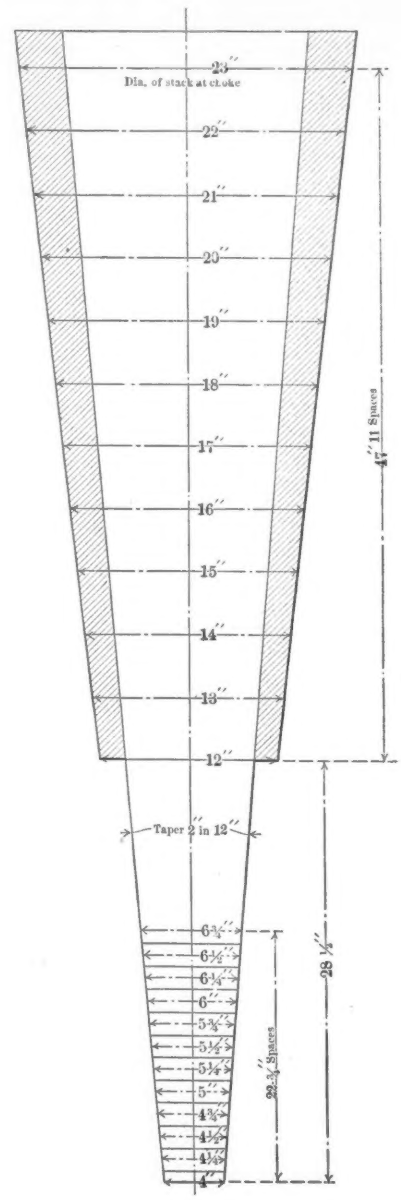


FIG. 2.

plate. For self-cleaning front ends, a damper which may be adjusted to give from ⅝ to ⅞ of the area of the tubes, will be found to give satisfaction. Allow a sufficient space for the working of this damper, and the height of the tip, which should be above the horizontal plate, will give the lowest possible nozzle.

It will be understood from the foregoing, that the rules given apply only to tapered stacks of the form recommended by the 1906 report, without draft pipes, and to the type of nozzle most commonly used. The remarks about dampers apply to "self-cleaning" front ends of the Lake Shore type.

HAL. R. STAFFORD.

SCHENECTADY, N. Y.

ANNEALING FIREBOX STEEL.

The question as to the advisability of annealing firebox steel is one that does not seem to be generally understood in connection with railroad boiler shop practice. The following notes, for which we are indebted to C. A. Seley, mechanical engineer of the Rock Island Lines, are of interest in this connection.

Authorities are not strong in urging annealing for boiler steel, principally because of the uneven results obtained by reason of crude methods employed, and the fact that exact temperatures that are necessary for results are not obtained. G. G. Mehrtens, Trans. A. S. C. E., 1893, says: "Annealing is of advantage to all steel above 64,000 pounds strength per square inch, but it is questionable whether it is necessary in softer steels. The distortions due to heating cause trouble in subsequent straightening, especially of thin plates." (Kent, page 395.)

Other authorities on boiler work and on metallurgy give the impression that annealing is so little practiced that the majority of boilers are built without it. It is not denied that annealing under proper management may be a benefit, but on account of methods employed, the wisdom of chancing injury is doubted.

Based on these opinions, the necessity for putting side sheets and most crown sheets into an annealing furnace is doubtful. They have not had such an amount of work in most cases as to introduce serious internal strains.

Assuming the necessity for annealing sheets that have been flanged or worked a considerable amount, the authorities have this to say as to proper methods. Kent says (page 395): "The best results from annealing will probably be obtained by introducing the material into a uniformly-heated oven in which the temperature is not so high as to cause a possibility of cracking by sudden and unequal changing of temperature, then gradually raising the temperature of the material until it is uniformly about 1,200 degrees F., then withdrawing the material after the temperature is somewhat reduced, and cooling under shelter of a muffle sufficiently to prevent too free and unequal cooling on the one hand, or excessively slow cooling on the other."

All authorities agree on the following points:

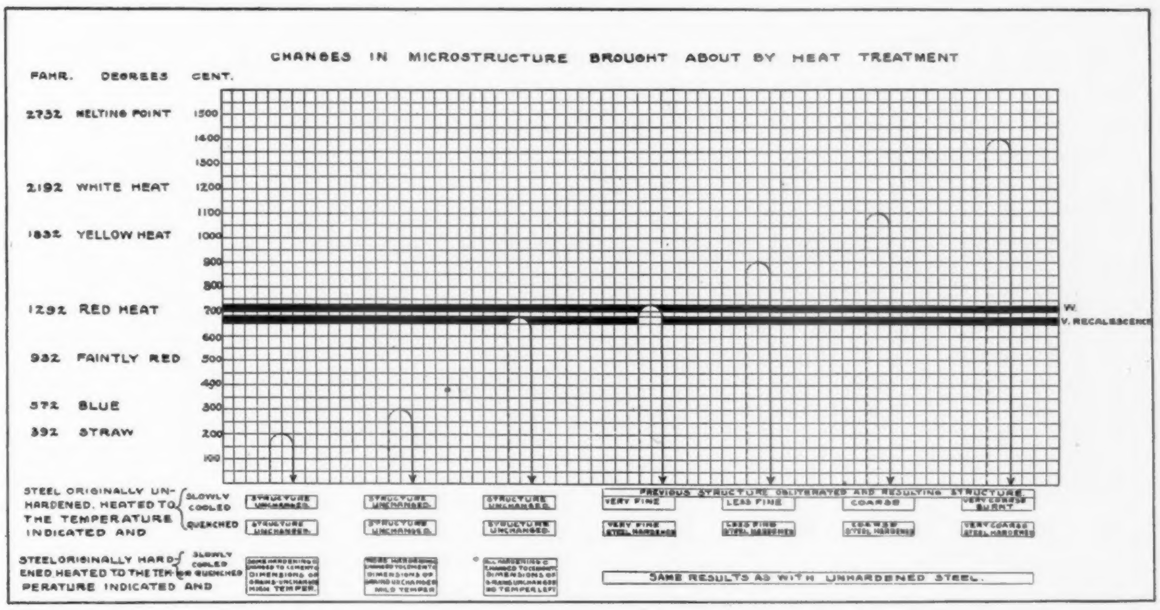
First: The steel should be heated slowly and evenly, the latter point being particularly observed.

Second: The maximum heat should be a bright cherry (Crescent Steel Co.) or medium orange (Wm. Metcalf, in "Manual for Steel Users," page 86). Heat should not go to bright orange or the lemon shades.

Third: As soon as thoroughly heated, as above, it should be removed from the fire, as "every additional moment of heating will only injure the steel ("Manual for Steel Users," page 86). "As soon as it is hot, take it out of the fire, the sooner the better, and cool it as slowly as possible" (Crescent Steel Co.). "Annealing for a short time at moderate temperature does not very largely increase the size of the grain, but prolonged heating at low temperature or comparatively short heating at very high temperatures produces a very coarse grained structure" (Harbord, Metallurgy of Steel, page 686).

Metcalf in "Manual for Steel Users," page 85, explains that steel will assume a structure dependent on temperature, hence the process of annealing is accomplished primarily by the heating to a proper temperature. With steels that harden, the amount of softness retained is a direct function of the length of time of cooling. In non-tempering steel this seems less important, and if reasonably even cooling can be secured, it is believed that nothing is gained by a prolonged period.

The accompanying diagram, illustrating this matter very clearly, is from "Harbord's Metallurgy of Steel." It shows the effect on the grain of the steel by heating up to various temperatures and then cooling down. It shows the height of temperature necessary to produce any change, and the bad effect of too high heat. It does not show bad effect of long continued low heat.



EFFECT ON THE GRAIN OF STEEL DUE TO HEATING UP TO VARIOUS TEMPERATURES AND THEN COOLING DOWN.
FROM "HARBORD'S METALLURGY OF STEEL."

To make the graphical diagram more valuable, the following table is reproduced from Kent, showing high temperature, judged by color, as follows:

	Deg. C.	Deg. F.
Incipient red heat	525	977
Dull red heat	700	1292
Incipient cherry-red heat	800	1472
Cherry-red heat	900	1652
Clear cherry-red heat	1000	1832
Deep orange heat	1100	2021
Clear orange heat	1200	2192
White heat	1300	2372
Bright white heat	1400	2552
Dazzling white heat	1500 to 1600	2732 to 2912

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.—The second annual convention of this association will be held at the Hotel Pontchartrain, Detroit, Mich., May 26, 27 and 28, 1908. The subjects, on which there will be committee reports and discussions, include,—the best method of applying and caring for flues; boiler explosions, cause and remedy; applying flexible staybolts; use of oil in locomotive boiler shops and subjects for discussion at the following convention. In addition to these there will be a number of topical discussions and individual papers. The secretary of this association is Harry D. Vought, 62 Liberty street, New York.

WOOD PRESERVATION.—It is estimated that a fence post, which will ordinarily last about two years, will, if given preservative treatment, costing about ten cents, last eighteen years.

COMBUSTION AND HEAT BALANCES IN LOCOMOTIVES.*

By Lawford H. Fry.

The heat losses in a locomotive boiler divide themselves into three main groups:—

1. Loss of heat in the products of combustion.
2. Loss of heat by external radiation.
3. Loss of heat by imperfect combustion.

These three losses with the heat usefully employed in the production of steam must account for all of the heat contained in the coal, and complete the heat balance.

(1) *Loss of Heat in the Products of Combustion.*—The products of combustion consist of certain dry gases, as shown by the analyses of the flue gases, and in addition to these a considerable amount of water-vapor from the water of combustion of the hydrogen in the coal, and from the moisture in the coal and in the air. There is also a trace of sulphuric acid from the combustion of the sulphur. In the St. Louis tests, the water of combustion with the sulphuric acid amounted to 0.40 lb. per pound of coal burned. The moisture in the coal was always in the neighborhood of 1 per cent., and therefore the water-vapor produced, per pound of coal burned, may be taken with sufficient accuracy as 0.41 lb. This comprises the water of combustion and the moisture in the coal as fired. In addition to this vapor, the moisture in the air admitted for combustion must be taken into account. The percentage of moisture in the air can be determined from the wet and dry thermometer readings* which were taken.

The mean figures thus obtained are:—

Series 100	1.25 per cent. moisture.
Series 200	1.18 " " "
Series 600	0.62 " " "
Series 800	0.48 " " "

These show that there was a considerable variation in the condition of the various series of tests, but in each series the individual tests do not show a wide variation from the mean.

The weight of the dry gaseous products of combustion per pound of coal burned is 0.54 lb. more than the weight of air supplied per pound of coal.

The amount of heat carried off by the products of combustion depends on the weights of dry gas and water vapor produced per pound of coal burned; on the temperature at which they escape to the smoke-box; and on the specific heat of these substances.

(2) *Loss of Heat by External Radiation.*—This loss was not measured in the St. Louis tests, and, as the loss by unburnt coal was not measured, the radiation loss cannot be determined by difference. It seems, however, permissible to assume that the loss by external radiation is 5 per cent. of the heat utilized by the boiler in evaporation. This cannot introduce any essential error, and it harmonizes with the little that has been published on this subject. Professor Hitchcock shows a loss up to 3.61 per cent., which is 6.3 per cent. of the heat of evaporation. Professor Goss says that experiment has shown that a locomotive running at 28 miles an hour loses by external radiation about 2 per cent. of the power developed.

(3) *Loss by Imperfect Combustion.*—This falls under two heads:—

(i) Loss by production of carbon-monoxide.

(ii) Loss by escape of unburnt coal at chimney and ashpan.

(i) The first-mentioned loss can be calculated from the analysis of the flue gases. The Pennsylvania report shows the percentage of loss in each test by the production of CO. There is a general tendency for the loss by CO to increase as the rate of combustion is increased, but except in Series 100 there is no very serious loss on this score. In Series 100 one individual test shows a loss of 16.33 per cent. by CO. This is due to the rapidity with which the air-supply falls off as the rate of combustion is increased. Evidently the difficulty of getting air to the fire limited the power of this boiler and prevented the rate of combustion being pushed above 90 lbs. of coal per square foot per hour. The relation between the loss of heat by CO and the rate of combustion in this case varies so much that it is difficult to draw a mean curve to express this relation with proper accuracy.

(ii) The loss of heat by the escape of unburnt coal is the most important loss in the heat balance when the boiler is working at full power. The coal escapes unburnt in three ways:—

(*a*) Partially unconsumed as sparks.
(*b*) Partially unconsumed in the ashpan.
(*c*) As unconsumed gas in the products of combustion. This last entails a secondary loss by
(*d*) The sensible heat of the unconsumed gas in the smoke-box.

As the necessary observations were not taken, it is not possible in the present tests to determine the separate value of each of the four items of the loss by unburnt coal, but the total amount of heat lost can be determined by the method which is described below, and which is illustrated by the following example:—

In Test 8,006 there is known	Per cent.
Heat of evaporation	47.20
Heat lost by external radiation	2.36
Heat lost in the production of CO	0.70
	50.26
This leaves as the loss to be divided between the products of combustion and unburnt coal	49.74
	100.00

The heat lost in this test in the products of combustion is 19.30 per cent. of the total heat of the coal *actually burned.* Now, if for example, 25 per cent. of the coal were to escape unburnt, the loss in the products of combustion would apply only on the remaining 75 per cent. actually burned, and would be 0.75×19.3, or 14.5 per cent. of the heat of all the coal fired. Consequently, if P is the percentage of heat lost by coal escaping unburnt, the loss in the products of combustion is $\frac{100 - P}{100}$ 19.3 per cent. of the total coal *fired,* or calling this P_1 we have

$$P_1 = \frac{100 - P}{100} 19.3$$

$$\text{and} \quad P_1 + P = 49.74$$

whence, by simple algebra, it is found that P, the loss by unburnt coal, is 37.70 per cent.

The general case is as follows:—

The calculations determine the loss in the products of combustion (including excess air) as a percentage of the total heat of the *coal actually burned.* In the heat balance this loss must be expressed as a percentage of the total heat of *all the coal fired.* If of the coal fired, P per cent. escapes unburnt, the figures must be reduced in the proportion* $\frac{100 - P}{100}$ to show the loss of heat in the products of combustion as a percentage of the heat in the coal fired. Represent this percentage by P_1. Then, if X be the quantity required to complete the heat balance as in the above example,

$$P + P_1 = X.$$

Let P_2 be the percentage of heat lost in the products of combustion per pound of coal burned; then, as explained above,

$$P_1 = \frac{100 - P}{100} P_2 \qquad (4)$$

$$\text{thence} \quad P + \frac{100 - P}{100} P_2 = X;$$

$$\text{and} \quad P (100 - P_2) = 100 (X - P_2);$$

$$\text{and} \quad P = \frac{100 (X - P_2)}{100 (- P_2)} \qquad (5)$$

and X and P_2 being known, P, the loss by unburnt coal, can be found. Having found P from equation (5), P_1, the loss by the products of combustion per pound of coal fired, is found from

* Extracts from a paper presented before the Institution of Mechanical Engineers at the meeting on March 27, 1908.

* This is an approximate factor to simplify the calculation. The exact factor would be $\frac{100 - P + d}{100}$, where d is the loss by the sensible heat in the unconsumed gas as a percentage of the total heat in the coal fired. The effect of d is so small that it is negligible.

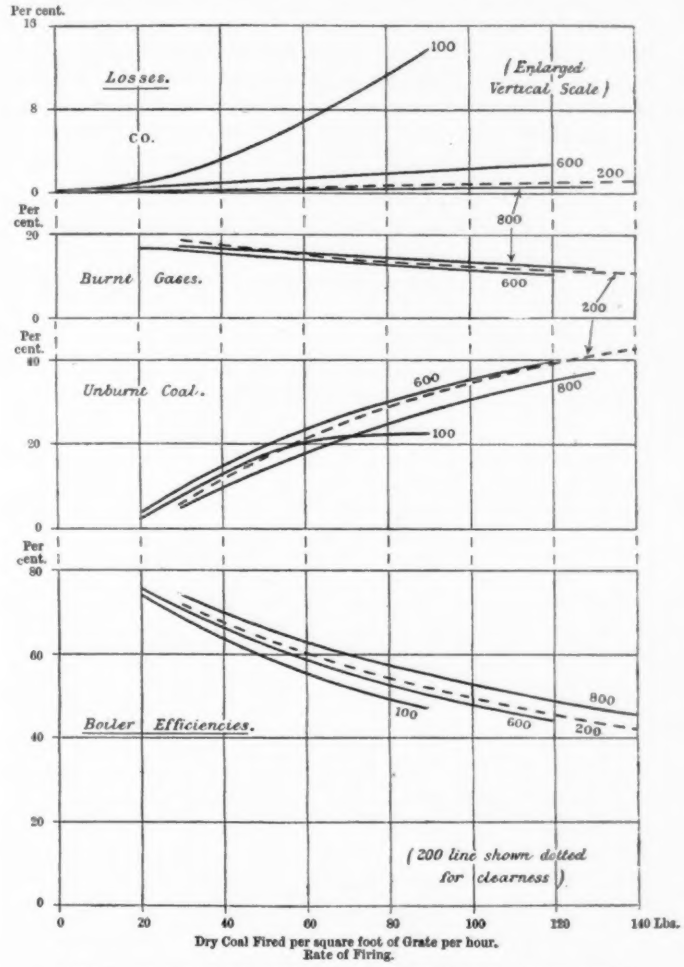
equation (4). The losses thus found complete the heat balance.

TESTS AT ALTOONA WITH BITUMINOUS COAL.

At the close of the St. Louis Exhibition, the Locomotive Testing Plant was transferred to the shops of the Pennsylvania Railroad, where it is now in regular operation. A series of tests were made with one of the standard Pennsylvania Railroad single-expansion Atlantic type locomotives which has cylinders 20½ inches in diameter, with 26 inches stroke, and driving wheels 6 feet 8 inches in diameter.

Three series were run: (a) with the full grate area of 55.5 square feet; (β) with the front of the grate covered with firebrick so that the effective grate area was reduced to 39.5 square feet, the ratio of grate area to heating surface being 1 to 58.7; (γ) with the effective grate area still further reduced to 29.76 square feet, giving a ratio of grate area to heating surface of 1 to 77.9.

In each of the series four tests were run, one at 80 revolutions per minute with a nominal cut-off at 15 per cent. of the



LOSSES OF HEAT IN LOCOMOTIVE BOILERS—ST. LOUIS TESTS.

stroke, one at 120 revolutions with 20 per cent. cut-off, one at 160 revolutions with 25 per cent. cut-off, and one at 160 revolutions with a cut-off of 32 per cent. This last combination of speed and cut-off taxed the boiler to its maximum capacity.

The coal used contained more volatile matter than that used at St. Louis (35 per cent. instead of 16 per cent.) and was less friable. An ultimate analysis was not made. The proximate analysis of the coal was:—

Fixed carbon	57.2 per cent.
Volatile combustible	35.0 " "
Ash	6.7 " "
Moisture	1.1 " "

[The author here analyzed the processes of combustion in the three series of tests by the same methods used for the St. Louis tests.]

In analyzing this series of tests the rate of combustion has been measured by the total weight of coal fired per hour, and not as for the St. Louis tests by the weight of coal fired per square foot of grate area per hour. This has been done because it was found that if any given quantity of coal, as for instance 4,000 pounds, is fired per hour, the boiler efficiency is independent of the grate area, being practically the same whether the coal is burned on the grate of 55.5 square feet at 72 pounds per square foot, or on the grate of 29.76 square feet at 134 pounds per square foot per hour. The reason, of course, is that in the three series of tests the firebox volume is the controlling factor in the combustion, and is constant; so that a given quantity of coal has in all three tests practically the same opportunity of complete combustion irrespective of the rate at which it is fired per square foot of grate.

SUMMARY OF RESULTS.

St. Louis Tests.—The calculations which have been described have determined for various rates of firing for each locomotive the values of the five items of the heat balance.

(1) Loss by formation of CO.
(2) Loss of heat carried off in the products of combustion.
(3) Loss by coal escaping unburnt.
(4) Loss by external radiation (assumed).
(5) Useful heat of evaporation.

The various values found for these items (with the exception of the radiation) are shown by the accompanying curves. From an examination of these it will be seen that they are calculated for rates of firing of from 20 to 140 lbs. of dry coal per square foot of grate per hour, and that within these limits the four chief items of the heat-balance are affected as follows by an increase in the rate of firing:—

The loss by CO increases from a trace up to about 2 per cent. except in series 100, which is abnormal in this respect, and shows losses up to about 13.8 per cent.

The loss of heat in the gaseous products of combustion decreases from about 18 per cent. to about 11 per cent.

The loss by unburnt coal increases from about 4 per cent. to about 40 per cent.

The boiler efficiency, being affected by the combination of the above changes, decreases from about 74 per cent. to about 43 per cent.

The heat-balances show the result of two separate operations within the boiler, viz., the production of heat by combustion in the fire-box and the absorption of heat by the heating surface. It is interesting to separate the efficiencies of these two operations.

The losses by CO and by unburnt coal are due to incomplete combustion and affect the efficiency of that process only, while the loss of heat in the gaseous products of combustion determines the efficiency of the heat-absorption.

It appears from these figures that the efficiency of the absorption of the heat is practically independent of the rates of combustion and evaporation, so that under all conditions of working the heating-surface absorbs about 81 per cent. of the heat produced by combustion. Approximately, the same figure is obtained for all four boilers, although they vary considerably as regards design and ratio of heating-surface to grate area. The figures show that the efficiency of the boiler, as a whole, is mainly determined by the efficiency of the combustion, which falls rapidly as the rate of combustion is increased.

Although the smoke-box temperature at which the products of combustion escape increases as the rate of combustion increases, the percentage of the total heat carried away by these gases is reduced. This is due to the reduction of the weight of gas produced per pound of coal burned. When the rate of firing is increased from 30 to 130 lbs. per square foot of grate, the weight of the products of combustion is reduced from about 18 lbs. to about 8.5 lbs. per pound of coal fired. For complete combustion about 11 lbs. of air are required, so that when the boiler was forced it was not possible to get enough air through the fire to burn all the coal fired.

The figures obtained show that the locomotive of series 100 is particularly choked for want of air. The author learnt with much interest, after writing the foregoing, that since the tests, the Pennsylvania Railroad has increased the area of the air-inlets in the ashpan of this locomotive, with the result that it steams much more freely and efficiently.

Altoona Tests.—The heat-balances in these tests are calculated for rates of firing ranging from 2,000 to 5,000 pounds of coal per hour. Within these limits, which correspond to the range covered by the tests at St. Louis, the four chief items of the balance are affected as follows by an increase in the rate of firing:—

The loss by CO increases from 0.4 to 2.4 per cent.

The loss of heat in the gaseous products of combustion decreases from about 18 per cent. to about 15 per cent.

The loss by unburnt coal increases from about 10 per cent. to about 28 per cent.

The boiler efficiency decreases from about 68 per cent. to about 52 per cent.

The efficiency of the absorption of the heat actually produced, is, as found in the St. Louis tests, practically independent of the rates of combustion and evaporation, varying only from 78.4 to 79.7 per cent. That is, under all conditions of working, the boiler absorbs about 79 per cent. of the heat produced by combustion, while the boilers at St. Louis showed a constant efficiency of absorption of about 81 per cent.

The Altoona coal, having a higher percentage of volatile matter than that used at St. Louis, did not give quite such a high boiler efficiency at the lightest loads, but it enabled the boiler to be forced to a higher rate of evaporation, and gave a higher efficiency at the maximum boiler power. In the St. Louis tests the highest rate of evaporation obtainable was about 16.3 pounds of water from and at 212° F. per square foot of heating surface per hour, the corresponding boiler efficiency being about 46 per cent. The tests at Altoona show a maximum evaporation of 18.6 pounds of water per square foot of heating surface per hour, with a boiler efficiency of about 51 per cent.

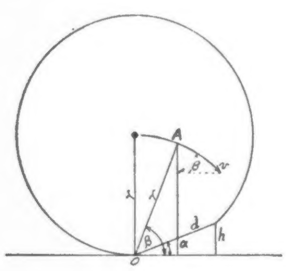
In examining the effect of the variation of grate area in the Altoona tests, it is found that at any given rate of evaporation there is very little difference between the efficiencies of the three series. At the lower rates of evaporation the largest grate gives the lowest efficiency and the smallest grate the highest efficiency; while at the high rates of evaporation the reverse is the case, the largest grate giving the highest efficiency. This is due to the fact that the resistance to the passage of the air through the grate is least with the large grate and greatest with the small grate. At low rates of combustion the most important losses are those due to an excess of air; consequently the large grate has the lowest efficiency. At the high rates of combustion the most important losses are those due to coal escaping unburnt from a lack of sufficient air for proper combustion, and hence the largest grate by admitting the air most freely gives the highest efficiency.

ALLOWABLE LENGTH OF FLAT SPOTS ON CAR AND LOCOMOTIVE WHEELS.*

BY E. L. HANCOCK, PURDUE UNIVERSITY.

In the absence of experimental data as to the impact to which rails are subjected because of flat spots on car and locomotive wheels, the author has made a theoretical analysis. The development of a formula for the energy with which a flat wheel strikes the rail is as follows:

Let the diagram represent the wheel, of radius, r, having a flat of length, d. Represent the velocity of the train by v. At any instant it may be considered that the kinetic energy of the wheel, with its weight, considered as rotating about the point, O, is the same as if the mass supported by the wheel be regarded as concentrated at its center, that is, its kinetic energy is $\frac{1}{2}Mv^2$, where M is the combined mass of the car and wheel and v is the velocity of train. When the flat spot is in contact with the track the center of the wheel is at the point A, distant below the original position approximately $\frac{1}{4}h$, which is equal to $d^2 \div 4D$, where d is the length of the flat spot and D is the diameter of the wheel. At the point A the mass has a downward velocity equal to v cos β.



But cos β equals $d \div D$, so that the kinetic energy with which M strikes the rail is $\frac{1}{2}Mv^2\cos^2\beta = \frac{Mv^2 d^2}{2D^2}$, where v is the velocity of train in feet per second, d the length of flat spot in feet and D the diameter of the wheel in feet.

It is assumed that the permissible kinetic energy of the blow caused by the flat spot should not exceed the kinetic energy with which the weight strikes a rail in the prescribed drop test. Hence the energy of the impact as deduced is equated to 380,000 foot-pounds, the energy of a 2,000-pound weight falling through 19 feet.

The weight upon a car wheel being assumed to be 10,000 pounds and the diameter of the wheel 33 inches, the formula becomes $d = \frac{29.4}{v}$ ....(A)

While the energy of impact will be slightly increased by reason of the action of gravity increasing the velocity of the mass during the fall through the distance of A below the center, approximately $\frac{h}{4}$, it is found that this is so small as not appreciably to affect the results.

A formula corresponding to (A) for a 72-inch driving wheel, assuming a load of 25,000 pounds on the driver, is:

$d = \frac{40.6}{v}$ ....(B)

The following table shows the values of d for various speeds:

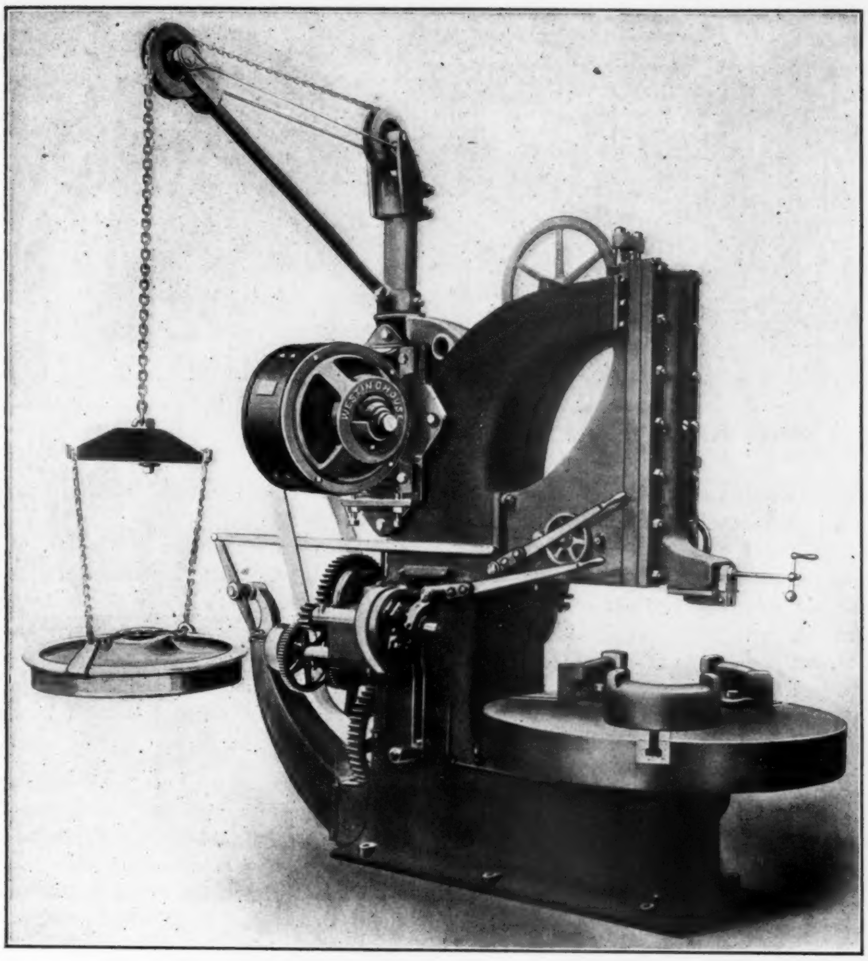
LENGTH OF FLAT SPOT PERMISSIBLE.

Speed v, in m. p. h.—	33-inch wheel—Formula A. d in ft.	Factor of safety of 10, d in in.	72-inch wheel—Formula B. d in ft.	Factor of safety of 10, d in in.
10	2.90	3.48	4.06	4.87
20	1.42	1.68	2.03	2.43
30	0.96	1.15	1.35	1.62
40	0.73	0.87	1.01	1.21
50	0.59	0.70	0.81	0.97
60	0.49	0.58	0.67	0.80
70	0.42	0.50	0.58	0.69
80	0.36	0.43	0.50	0.60
90	0.32	0.38	0.45	0.54
100	0.29	0.34	0.41	0.49

* From a paper presented before the Indiana Engineering Society, January 17, 1908.

COMPARISON OF ALCOHOL AND GASOLENE ENGINES.—A very complete set of tests on the relative value of gasolene and alcohol as producers of power has recently been made by the Technologic Branch of the United States Geological Survey. Over 2,000 tests were made and it is stated that the results show that correspondingly well designed alcohol and gasolene engines, when running under the most advantageous conditions for each, will consume equal volumes of the fuel for which they are designed. The minimum fuel consumption value thus obtained is .8 of a pint per hour per brake h.p. Considering that the heat value of a gallon of denatured alcohol is only about .6 that of a gallon of gasolene, this shows a much better thermodynamic efficiency for the alcohol engine.

SAILORS RIDE IN RAILWAY GASOLENE MOTOR CAR.—A feature of the celebration of the arrival of the battleship fleet at San Diego, Cal., was a new gasolene motor car, of the same type as used on the Union Pacific Railway, which the Los Angeles & San Diego Beach Railway has recently installed. The trip of this car to the coast was exceptional for this class of equipment, since it was ordered at such a late date that it was necessary to start it from Omaha without the customary breaking in trials. The car left Omaha on April 9 at 5 A. M. and arrived at Los Angeles at 3 P. M., April 13, having made the entire run without mishap or delay of any kind.



SELLERS MOTOR DRIVEN CAR WHEEL BORING MILL.

MOTOR DRIVEN CAR WHEEL BORING MILL.

A recent type of Sellers 54-inch motor driven car wheel boring mill, with improved automatic chuck, friction feed discs and crane attachment, is shown in the illustration. The machine is of heavy, substantial construction, capable of taking the heaviest cuts required for this class of work.

The chuck closes, centers and opens automatically. It has three adjustable abutments, as shown, each provided with an equalizing steel jaw, with two bearing points. The work is thus accurately centered by six points on the circumference. The first movement of the driving shaft causes the jaws to close in upon the wheel, after which the motion is transmitted to the table to produce rotation. When the work is completed the chuck is released by disengaging the driving clutch and retarding the driving shaft by means of a friction brake. The inertia of the table and work imparts the necessary force to automatically open the jaws without loss of time. As the power of the clutch grip increases with the resistance of the cut it is never necessary to stop the machine to tighten the chuck.

A Westinghouse type S, 7½ h.p., motor is mounted on the frame of the machine, provision being made for a vertical movement of the motor on its base for tightening the belt. The motor has a variation in speed of approximately 2 to 1. The motor furnishes a number of speed steps within this range, so that the machine thus equipped can be operated more efficiently than the belt drive with cone pulleys.

A HUNDRED MILLION TIES A YEAR.

In the construction of new track and for renewals, the steam and street railroads used, in 1906, over one hundred million crossties. The average price paid was 48 cents per tie. Approximately three-fourths of the ties were hewed and one-fourth sawed.

Oak, the chief wood used for ties, furnishes more than 44 per cent., while the southern pines, which rank second, contribute about one-sixth. Douglas fir and cedar, the next two, with approximately equal quantities, supply less than one-fifteenth apiece. Chestnut, cypress, western pine, tamarack, hemlock, and redwood are all of importance, but no one of them furnishes more than a small proportion.

Oak and southern pine stand highest in both total and average value; the average value of each is 51 cents. Chestnut ranks next, followed by cedar. Hemlock, at 28 cents, is the cheapest tie reported.

More than three-fourths of all ties are hewed. In general, when lumber has a relatively low value the proportion of sawed ties increases, because the market for ties is always active, while that for lumber is frequently sluggish. All western species are affected by this condition, for stumpage is abundant and its value relatively low.

Ten per cent. of the ties purchased were treated with preservatives either before they were purchased or at the treating plant of the railroad company. At least ten railroad companies are operating their own plants for the preservation of their construction material.

It has been calculated that the amount of wood used each year in ties is equivalent to the product of 600,000 acres of forest, and that to maintain every tie in the track two trees must be growing.

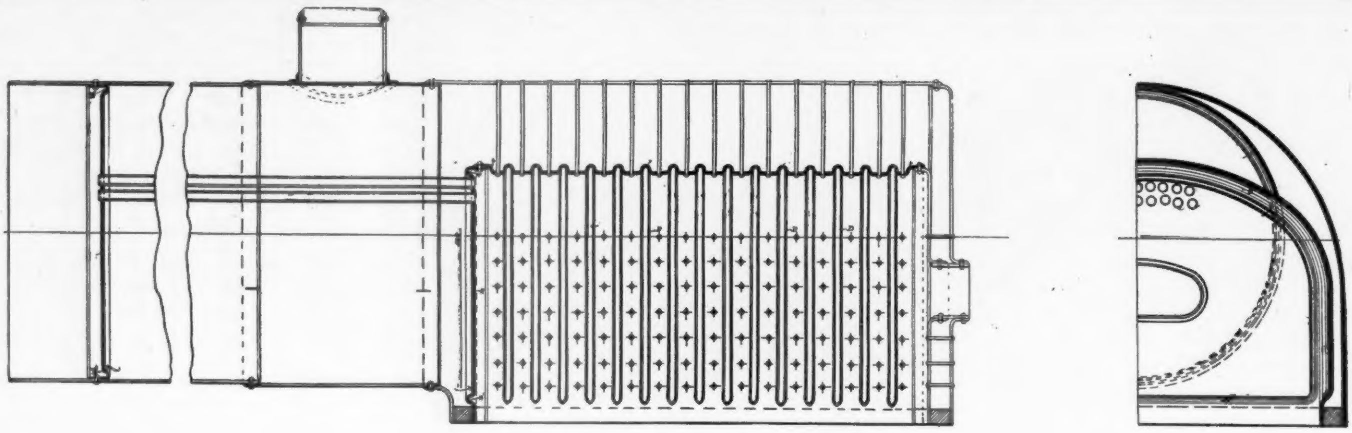
With nearly 300,000 miles of railroad trackage and approximately 2,800 ties to the mile, there are over 800,000,000 ties constantly subject to wear and decay. The railroads report that in the forms of ties cedar lasts eleven years, cypress ten years, and redwood nine years. These woods, however, lack the desired weight and hardness, and, what is more important, they are not available in the region of the trunk lines of the Central and Eastern States. When it is considered, then, that the service of the longest-lived tie timbers in general use—chestnut, white oak, tamarack, spruce, and Douglas fir—is but seven years, while with some, as the black oaks, it is but four years, whereas a treated tie with equipment to lessen wear will last fifteen years, it is apparent how much the railroads can save if preservative treatment of ties is universally adopted. The saving in the drain upon the forests is of even greater moment.

Details of the consumption of ties in 1906 are contained in Circular 124, just issued by the Forest Service in co-operation with the Bureau of the Census. This pamphlet can be secured by application to the Forester at Washington, D. C.

HIGH SPEED STEEL.

In a discussion regarding the manufacture and up-keep of milling cutters, at a meeting of the Institution of Mechanical Engineers, of Great Britain, one of the speakers called attention to a valuable property of high-speed steel, which he had not seen referred to, namely, that of withstanding shocks. In one of the railway shops in England, the output of the crank-turning lathes had been practically doubled by the use of high-speed steel tools. The forgings were never very accurate, there being perhaps ¼ inch to take off one side of the diameter, and 1½ inch off the other, and a tool suited to such wide variation was greatly appreciated. If the high-speed steel tool dug in, it did not break, as invariably happened with ordinary carbon steel.

Another speaker called attention to an important factor affecting the life of high-speed steel milling cutters. The teeth, besides being correctly relieved at the back, should have a front rake of 5 degrees. The number of teeth in milling cutters, par-



WOOD'S IMPROVED TYPE OF LOCOMOTIVE BOILER.

ticularly when made of high-speed steel, plays a very important part. A cutter made of this material with a large number of teeth, has a considerably shorter life than one with fewer but deeper teeth. In a certain case, two milling cutters, one with 16 teeth, and one with 32 teeth, had been made. The one with the coarser teeth, of helical shape, would finish an article with as good a finish as the one with the finer pitched teeth, but the cost of making the coarse-pitched cutter was 35 per cent. less than the cost of making the one with the fine-pitched teeth, and the life of the coarse-pitched cutter was four or five times as long as that of the other.—*Machinery.*

AN IMPROVED LOCOMOTIVE BOILER.

An attendant at any of the railway mechanical conventions cannot help but be impressed by the lively interest which is taken in any papers dealing with improvements or suggested improvements of locomotive boilers. This is always a live and interesting subject and in spite of the care and attention that has been given it, during past years, dealing with both boiler construction and purification of feed water, there is no doubt but what leaky boilers are the source of more trouble and delay than any other feature of the locomotive.

Realizing these conditions and after studying the subject thoroughly for a long while, Mr. William H. Wood, an engineer of Media, Pa., has come to the conclusion that the trouble is due very largely to the construction of the boiler, principally on account of there being, in the ordinary locomotive boiler, practically no provision for taking care of the contraction and expansion, either in the fire-box or the flues. Following this decision he has designed improvements for locomotive boilers which he believes will overcome this difficulty and the accompanying illustrations show a boiler fitted as he suggests.

It will be noticed that the difference between this boiler and one of the ordinary type consist of a special form of flange for the front and back tube sheet, which will allow greater flexibility for taking care of the expansion of the flues, thus preventing the working of the flue in the sheet with consequent leaking. In addition, the fire-box sheets are made of steel pressed with vertical recesses equally divided in the length of the box, somewhat similar to the corrugations used in Fox and Morrison furnaces in marine work. In this manner the expansion of the crown and side sheets of the fire-box is equally distributed throughout the length of the sheet, being taken up by the flexibility of the flanged recesses instead of being concentrated at the edges as is the case with the plain sheets.

The illustration shows this fire-box as applied to a Wooten type, but the same principle will hold for soft coal fire-box. It might also be mentioned that, while the illustration shows the pressed steel fire-box used with the flexible flanges on the tube sheets, this type of flange can be used with the ordinary straight fire-box sheets, depending on the flexibility of the joint between the back tube sheet and the firebox for taking up the expansion.

It is believed by Mr. Wood that this type of boiler will be found to have the following advantages:

It will permit the flues to contract and expand without being loosened in the sheet.

It will provide for a vertical expansion of the tube sheet.

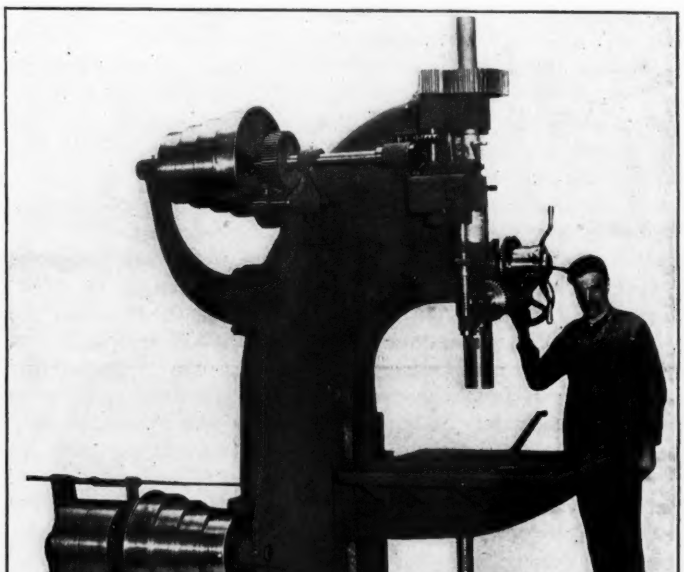
The heating surface in the fire-box, which is increased about 30 per cent., will result in an increased efficiency in the boiler.

A fire-box flanged in this form is necessarily much stronger and hence will need less staying.

Since a contraction and expansion of the box is equally divided between each staybolt that there will be much less total bending action of the staybolts at the ends and corners of the sheets and hence fewer broken staybolts.

HIGH DUTY DRILL.

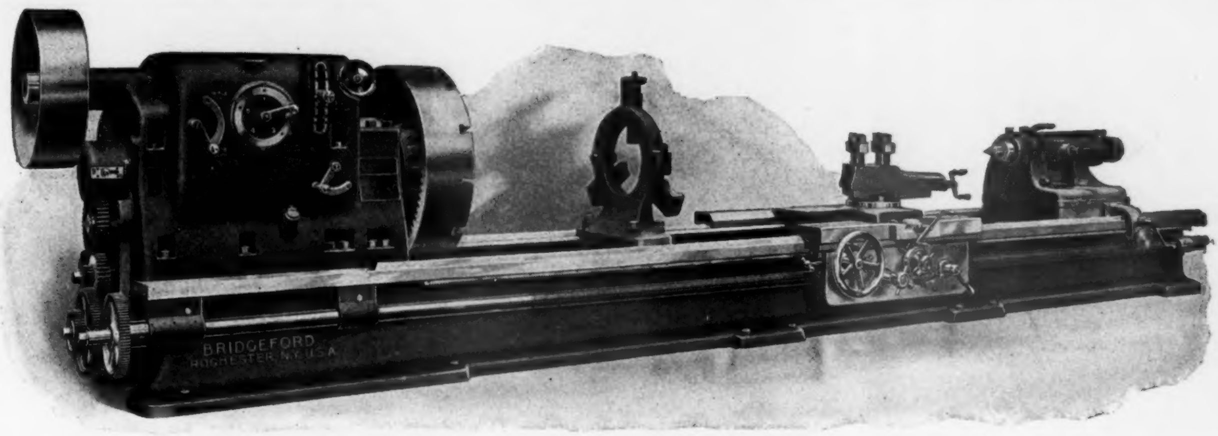
The Foote-Burt high duty drill shown in the photo is guaranteed to drive a 3½ in. high speed steel drill to its full cutting capacity in steel. The design and weight of the machine are such as to make it very rigid, there being no deflection between the point of the spindle and the table under the most severe service, thus making it possible to use the drills to their highest point of efficiency and without danger of breakage. These machines are



FOOTE-BURT HIGH DUTY DRILL.

made with two depths of throat, capable of drilling to the centers of 44 and 60 in. circles. They may be furnished with either a straight drive, as shown, or a right angle drive, and with either a compound or a plain table.

The spindle is 3½ in. in diameter in the sleeve, which is 23 in. long, and the maximum distance of the nose of the spindle from



BRIDGEPORT 42-INCH GEARED HEAD ENGINE LATHE—BRIDGEPORT MACHINE TOOL WORKS.

the top of the plain table is 32 in. The sleeve has ball bearing thrust collars using ¾ in. balls, which are warranted to stand the most severe service continuously without breakage of the balls or crushing of the collars. The change gear mechanism, located at the side of the spindle, provides three changes of feed (.007, .016, and .032 to a revolution), any one of which is instantly available by shifting the lever over the gear box. The box works on the "pull pin" principle as distinguished from the sliding key and may be thrown in or out while the drill is cutting without danger of damaging the mechanism. In addition to the power feed the machine is provided with a hand feed through worm and worm wheel and a quick return. The feeds are provided with automatic stops, which are adjustable and knock off the feed at any desired point. A safety friction device is also provided for the feed to prevent damage in case of accident.

Eight spindle speeds are provided by the four step cone pulleys and the back gears; with the counter shaft running at 350 revolutions per minute and the back gears in, the spindle speeds are 23, 30, 38 and 50 r. p. m.; with the back gears out the speeds are 80, 103, 133 and 170 r. p. m.

The table is fitted to the column by a square locked slide and is clamped by straps. Additional support is given underneath by a 3 in. square thread elevating screw, which acts as a solid jack in line with the spindle when the machine is in operation. The table is provided with an oil groove and has a working surface of 26 x 34 in. These machines are manufactured by The Foote-Burt Company, Cleveland, Ohio.

42-INCH GEARED HEAD ENGINE LATHE.

The 42-inch geared head engine lathe, illustrated herewith, is a recent design of the Bridgeport Machine Tool Works, Rochester, N. Y. It has been designed to meet the severest requirements and is provided with a mechanical means for quickly changing the spindle speed. Power is applied to a constant speed pulley and fifteen spindle speeds, in geometrical progression, are obtained through a speed variator. The levers for operating this device are conveniently located, as shown. All of the gears in the head run in oil. The gearing is proportioned to give from 2.26 to 110.8 revolutions of the driving pulley to one of the face plate. The pulling power on a 42 in. diameter is said to be 25,000 lbs. or about four times that of an ordinary cone driven lathe.

The lathe may be driven by a motor of from 25 to 40 h.p., according to the requirements. The motor is mounted on the head stock and the belt pulley is replaced by a silent chain sprocket, or a raw hide gear, as desired. A constant speed motor may be used, although the makers recommend one having a speed variation of 1½ or 2 to 1. With a variable speed motor the controller is operated from the carriage through a splined shaft. The bed is of a substantial and rigid design and has a longitudinal rib with a cast rack, with which a pawl at the back of the tail stock engages. This forms a positive stop for the tail stop, which is of considerable advantage when the lathe is engaged on heavy work. The 42-inch lathe with a 26-foot bed weighs 36,000 lbs. The same type of lathe is furnished with 26, 32, 36, 42 and 48 inches swing.

ROUND HOUSE WORK REPORTS.

TO THE EDITOR:

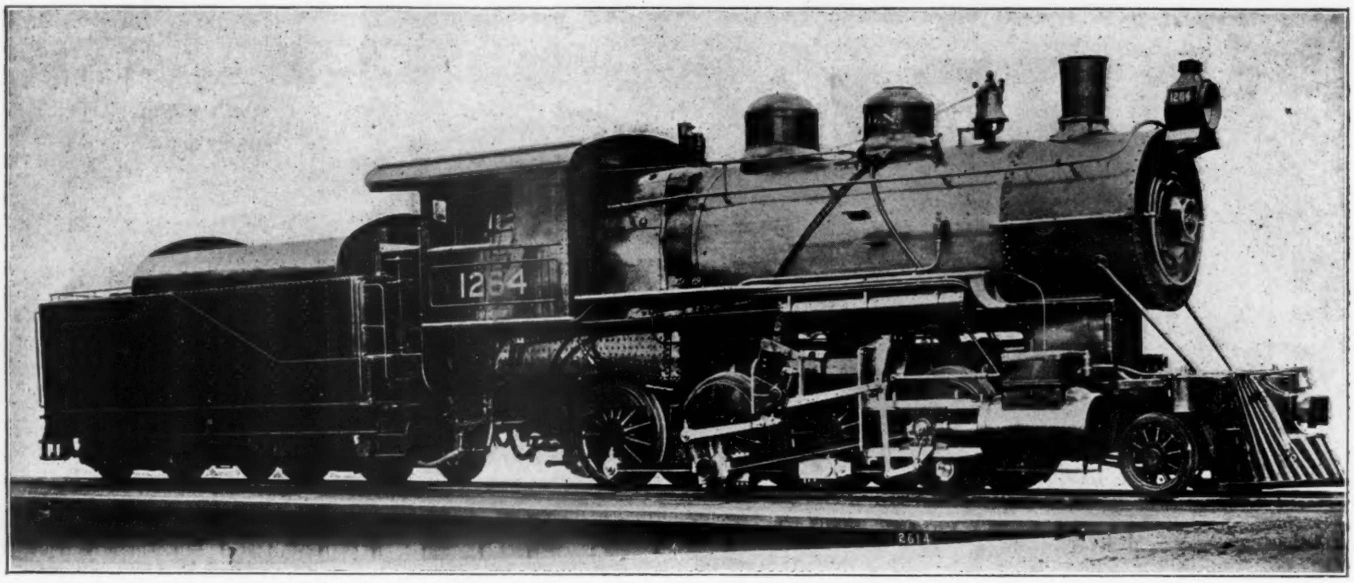
I would like to gain some information as to the best methods of handling roundhouse work reports. Our method is to keep the original report, which is made on a suitable form by the engineer, in the work book and supply each man with a small slip showing the work he is expected to do. This is not entirely satisfactory for two reasons: first, because of the large amount of clerical work involved, and second, while a record of the work each man is expected to do is in the work book we do not require his signature to the effect that he has done the work, which is important. The work slips are made on small pieces of plain paper and show the number of the engine, the work which is to be done and the name of the man who is to do it. It has been suggested that the workman might sign his name on the back of the slip after he had completed the work and turn it in, but as these slips are quite small it would be practically impossible to save and file them all, and even then it is doubtful if they would be of any value in a court of law.

We could give out the original work reports and have the men doing the work sign them on the back, but as it is oftimes difficult to decipher tnese when clean, it would be practically impossible to read them after they had been handled by several workmen. Do you know of any method in use which would overcome these difficulties?

DIVISION FOREMAN.

[EDITOR'S NOTE: We shall be pleased to hear from any of our readers who know of a more satisfactory method.]

APPRENTICESHIP EXHIBIT, RAILROAD MECHANICAL CONVENTIONS.—A novel feature of the Atlantic City conventions will be the exhibit of the committee on apprenticeship. It is expected that the railroads operating apprentice schools will send models, drawings and photographs to show in a comprehensive manner the rapid advancement which is being made in this phase of railroad activity. The following roads have thus far consented to exhibit: Central Railroad of N. J., Grand Trunk, Santa Fé and New York Central Lines. The members of the committee are C. W. Cross, superintendent of apprentices, New York Central Lines, chairman; G. M. Basford, assistant to president, American Locomotive Company; W. D. Robb, superintendent motive power, Grand Trunk; A. W. Gibbs, general superintendent motive power, Pennsylvania Railroad; B. P. Flory, mechanical engineer, Central Railroad of New Jersey; John Tonge, master mechanic, Minneapolis & St. Louis; F. W. Thomas, superintendent of apprentices, Santa Fé.



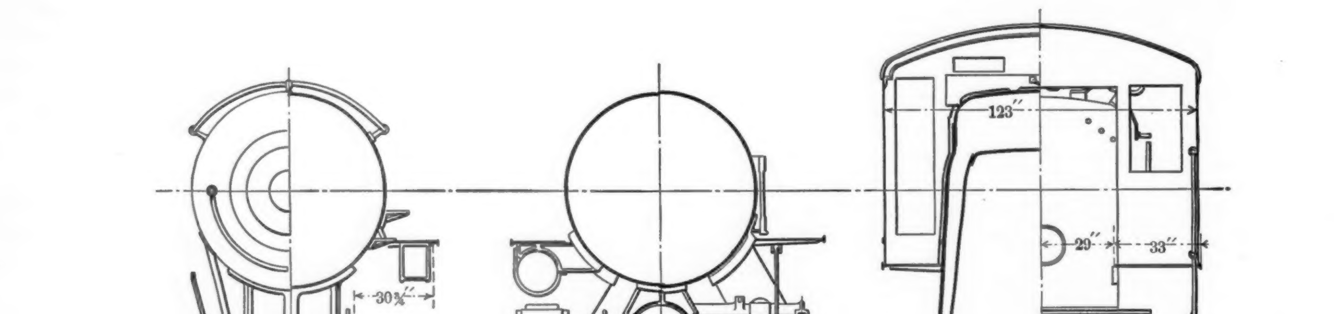
HEAVY CONSOLIDATION LOCOMOTIVE—GREAT NORTHERN RAILWAY.

CONSOLIDATION TYPE LOCOMOTIVE.

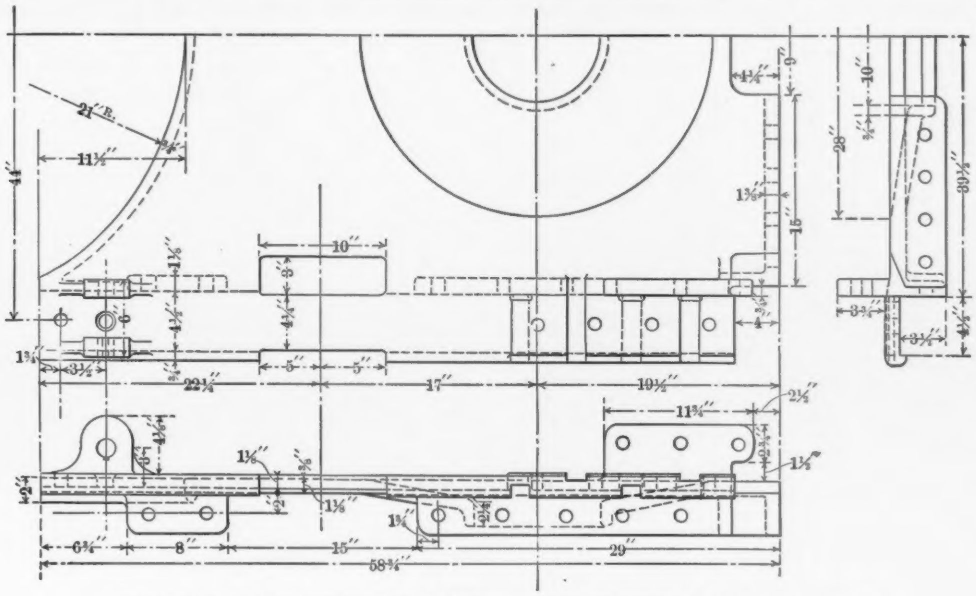
GREAT NORTHERN RAILWAY.

The Baldwin Locomotive Works has recently completed an order of 50 locomotives of the consolidation type for the Great Northern Railway. These engines are known in the road's classification as class F 8 and the general design was worked out in accordance with drawings furnished by the railway company. A somewhat unusual arrangement of Walschaert valve gear which was designed by the builders has been applied.

These locomotives have a total weight of 210,350 lbs., of which 188,250, or about 90 per cent., is on drivers. The cylinders, 20 x 32 in., with 55 in. drivers and 210 lbs. steam pressure give a theoretical tractive effort of 41,540 lbs. This gives a factor of adhesion of 4.53. The boiler is of the Belpaire type, conforming with the standard practice on this road. It has a vertical throat and back head with the crown and roof sheets slop-



SECTIONS AND ELEVATION OF HEAVY CONSOLIDATION LOCOMOTIVE—GREAT NORTHERN RAILWAY.



DETAILS OF FRAME STIFFENING CASTING—GREAT NORTHERN 2-8-0 LOCOMOTIVE.

ing somewhat toward the rear. These sheets are also slightly arched transversely. The water spaces at the mud ring are narrow, measuring but 4 in. for the front and 3½ in. on the sides and back. The barrel of the boiler is built up of two rings, each having a butt jointed sextuple riveted seam on the top center line. These seams are welded under the dome flange and at the ends. The boiler is amply provided with means for washing out, which include two 6 in. hand holes in the bottom of the barrel. It contains 331—2 in. tubes 14 ft. 8 in. long, giving a tube heating surface of 2,523.5 sq. ft. Seven and one-half per cent. of the total heating surface is located in the firebox. The grate area of 59 sq. ft. is larger than is commonly used with this amount of heating surface, and will allow the use of a very low grade of fuel.

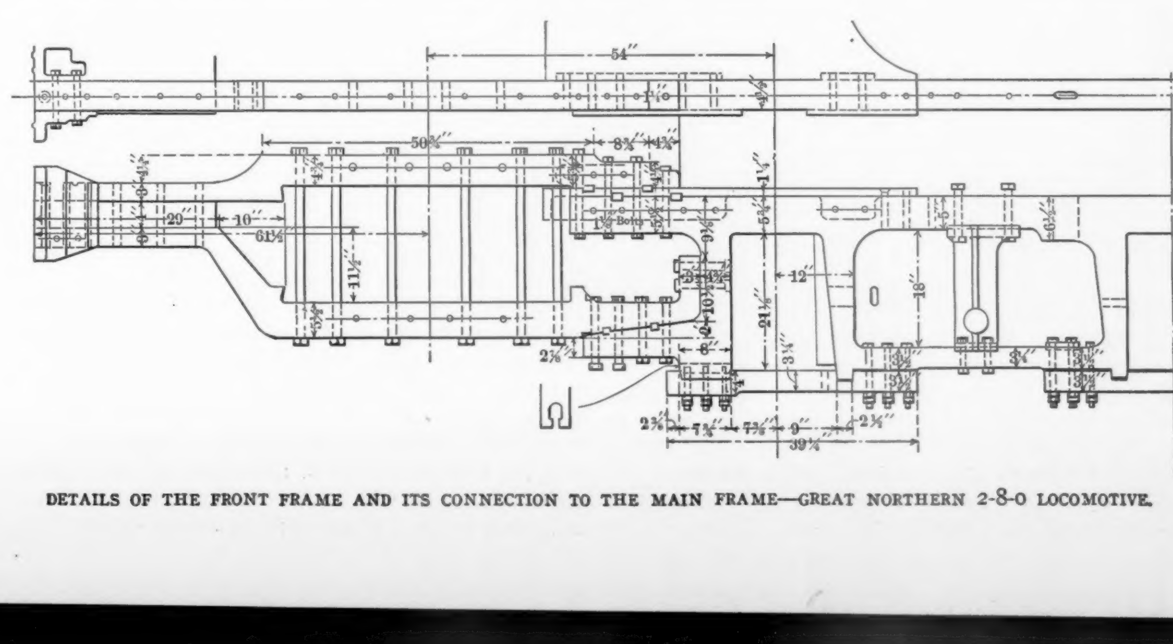
The design of Walschaert valve gear is based upon the fact that balanced slide valves are used and it was necessary to place the center of the valve stem 2¾ in. inside the center of the cylinders. This compelled the use of a rocker arm which is supported by the guide yoke. The links are carried by a special support, which spans the frames just back of the second pair of drivers, and is stiffened by a plate extending outside of the driving wheels to the guide yoke, and also by large cast iron knees, fastening it to the frame. This brace also supports the reverse shaft bearing, the arrangement being as shown in the general elevation of the locomotive.

The main frames are of cast steel 4½ in. wide, with two wrought iron front rails, which span the cylinder casting. They are securely tied together at the front and back by cast steel foot plates and in addition are braced by a substantial steel casting located just back of the cylinder saddle. This casting and the front section of the frames are shown in one of the illustrations. It is unusually broad and extends back beyond the first pedestal. Lugs are provided to which the spring hanger is connected and the casting is double keyed and securely bolted to both the main frame and the upper front rail.

The tender trucks are of the pedestal type with equalizing beams over the boxes and semi-elliptical springs. The wheels have cast steel plate centers and the cast steel bolsters are set as low as possible in order to keep down the center of gravity.

The general dimensions, weights and ratios of these locomotives are given in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	41,540 lbs.
Weight in working order	210,350 lbs.
Weight on drivers	188,250 lbs.
Weight on leading truck	22,100 lbs.
Weight of engine and tender in working order	358,000 lbs.
Wheel base, driving	16 ft.
Wheel base, total	24 ft. 3 in.
Wheel base, engine and tender	54 ft. 7 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.53
Total weight ÷ tractive effort	5.05
Tractive effort × diam. drivers ÷ heating surface	840.00
Total heating surface ÷ grate area	46.20
Firebox heating surface ÷ total heating surface, %	7.50
Weight on drivers ÷ total heating surface	69.50
Total weight ÷ total heating surface	77.00
Volume both cylinders, cu. ft.	11.70
Total heating surface ÷ vol. cylinders	233.00
Grate area ÷ vol. cylinders	5.05
CYLINDERS.	
Kind	Simple
Diameter and stroke	20 × 32 in.
VALVES.	
Kind	Bal. slide
Greatest travel	6 in.
Outside lap	1 in.



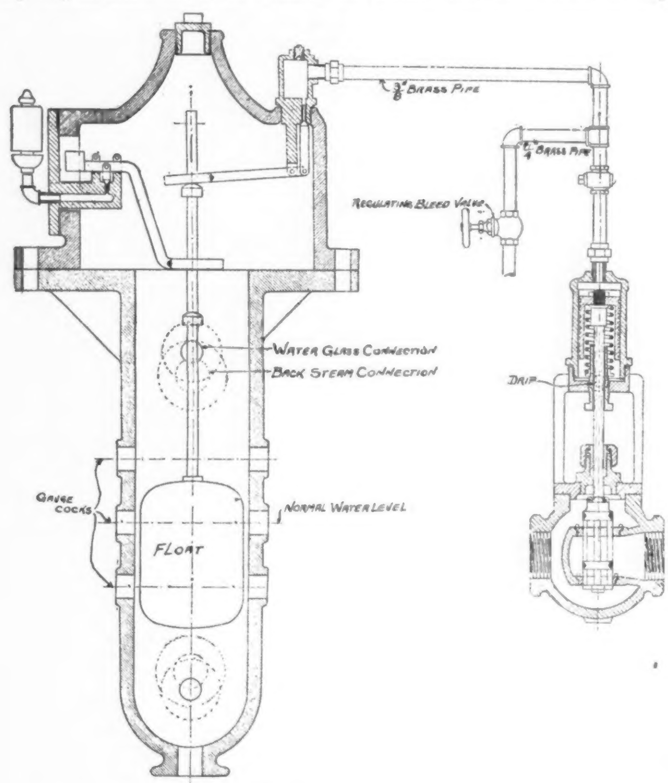
DETAILS OF THE FRONT FRAME AND ITS CONNECTION TO THE MAIN FRAME—GREAT NORTHERN 2-8-0 LOCOMOTIVE.

Inside clearance	0 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	55 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	9 × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6 × 12 in.
BOILER.	
Style	Belpaire
Working pressure	210 lbs.
Outside diameter of first ring	74⅛ in.
Firebox, length and width	118 × 72¼ in.
Firebox plates, thickness	⅜ and ⅝ in.
Firebox, water space	F-4 in., S & B-3½ in.
Tubes, number and outside diameter	331—2 in.
Tubes, length	14 ft. 8 in.
Heating surface, tubes	2,523.5 sq. ft.
Heating surface, firebox	204.0 sq. ft.
Heating surface, total	2,727.5 sq. ft.
Grate area	59 sq. ft.
Smokestack, height above rail	15 ft. 5¾ in.
Center of boiler above rail	9 ft. 6 1/16 in.
TENDER.	
Tank	Waterbottom
Frame	12 in. channels
Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	8,000 gals.
Coal capacity	13 tons

BOILER FEED WATER REGULATOR.

A new type of feed water regulator, simple in construction and reliable in action, which can be applied to any type of stationary boiler has been designed and is being manufactured by the Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburg, Pa.

This device is called the Gould Safety Continuous feed water regulator and includes a specially designed water column connected by a brass pipe to a controlling valve placed in the feed line of the boiler. The water column is cast iron and contains a copper float which carries a vertical rod fitted with two collars. By adjustment of these collars the water can be carried at any



GOULD SAFETY CONTINUOUS FEED WATER REGULATOR.

desired point in the boiler and the level can be maintained with a very small variation. When the water rises the upper collar on the rod comes into contact with a lever, which opens a small valve, permitting steam pressure to pass through the brass piping to the top of the piston forming part of the controlling valve in the feed line. This piston is then partially or wholly forced downward cutting off the supply to the boiler. When the water recedes the steam valve closes and the pressure in the pipe is gradually dissipated through the regulating bleed valve and the spring beneath the piston forces it up and permits the water supply to again enter the boiler.

The valve in the water end of the feed controlling valve is of the balanced slide valve type, so constructed that any amount of back pressure in the feed line will have no effect in overcoming the steam pressure on top of the small piston. The bleed valve is capable of very close adjustment and can be so adjusted as to make the regulator hold the water level with a very slight variation.

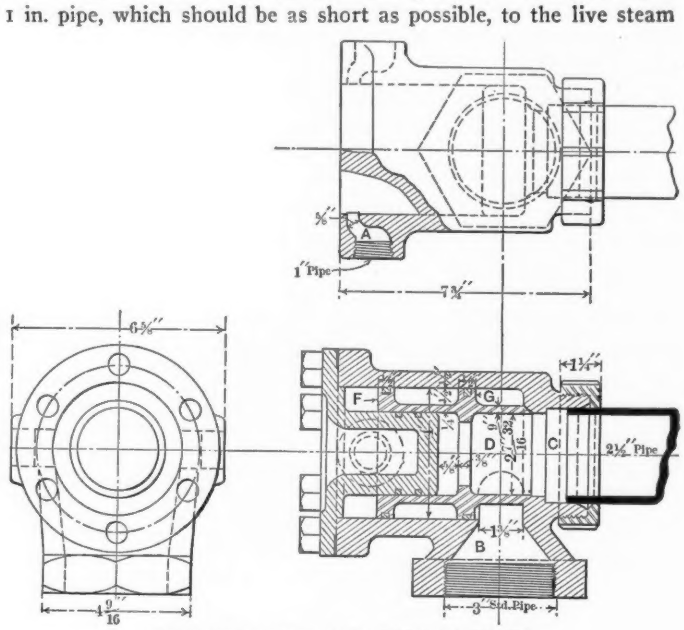
The water column is also provided with a high and low water alarm, so constructed that it can be removed and replaced in a few moments without disconnecting the top part of the column. This alarm consists of a whistle and a small valve, which is operated by an arm arranged to come in contact with either the upper or lower collar on the float rod and thus open the valve and permit steam to blow the whistle at the water level for which the collars are adjusted.

The parts of this apparatus forming valve seats and valves, as well as the small cylinder and piston of the operating valve and the piping throughout are made of brass, the other sections being of cast iron. Provision is made for attaching a water glass and gauge cock to the water column.

CYLINDER RELIEF AND VACUUM VALVE.

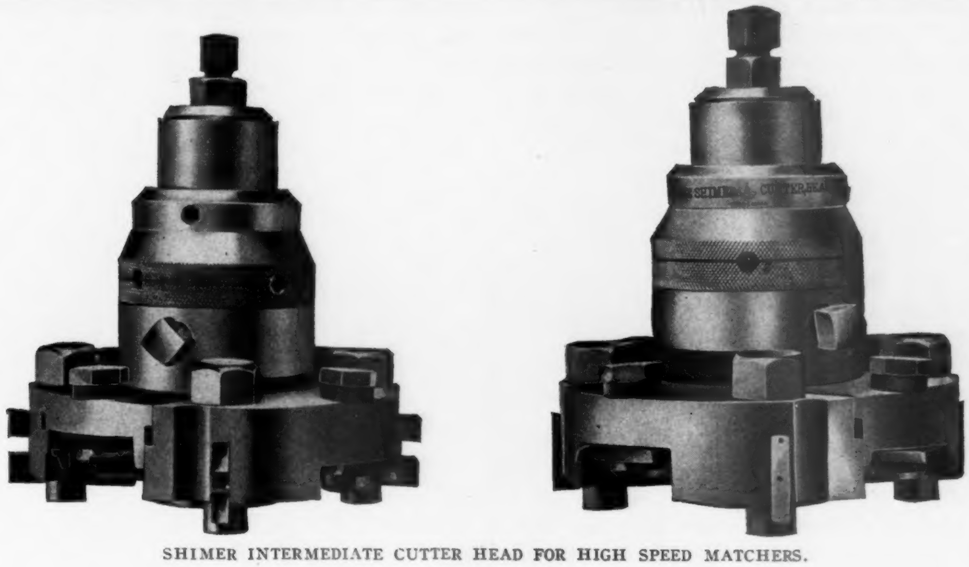
A new type of cylinder relief and vacuum valve has been desinged by Messrs. B. O. Yearwood and R. C. Patterson, of Portsmouth, Va. This valve is comparatively simple in construction and has proved itself to be very reliable in practical service. Its operation is obtained from the presence or absence of pressure in the steam chest and it does not contain any springs or adjustable parts.

The illustration shows the construction quite clearly; referring to the lettered passages and parts the operation and connection of the valve are as follows: The port A is connected by a 1 in. pipe, which should be as short as possible, to the live steam



CYLINDER RELIEF AND VACUUM VALVE.

chamber in the steam chest. This pressure then acts against face F of the valve, holding it against its seat, overcoming the resistance of the pressure against face G, which is from 15 to 20 per cent. smaller in area, and is subjected to pressure from the cylinder, connection being by a 3 in. pipe, through passage B. Passage C connects to a similar passage in a similar valve at the opposite end of the cylinder by a 2½ in. pipe. When for any reason the pressure on the cylinder rises to a point 15 or 20 per cent. above the boiler pressure the valve is then forced open and the pressure relieved through the port C to the other side of the piston. When the throttle is closed and the locomotive begins to drift the compression in the cylinder will force the valve open and the vacuum created in the steam connection will hold it in that position, allowing a free passage on both sides of the piston, from one end of the cylinder to the other.



SHIMER INTERMEDIATE CUTTER HEAD FOR HIGH SPEED MATCHERS.

INTERMEDIATE CUTTER HEAD FOR HIGH SPEED MATCHER.

A new cutter head for use on high speed matchers has recently been developed which offers several features of advantage over the ordinary types for this purpose. The head is made in two sections, and provides for perfect expansion of the tongue and grooved proportions. In this tool straight and circular bits are used in combination, the straight bits, used for cutting the vertical edge of the board, being made from flat strips of self-hardening steel. The square offsets above and below the tongue are formed by grooving out the end of the bit and projecting it to the proper distance. The finish is accomplished by the intermediate circular bits working in pairs in the upper and lower series.

Of the two sections of the head the one forming the body is a solid steel forging bored and turned to a true cylindrical form. The lower portion of the flange of this section is grooved radially at equal distances around the head in order to receive the straight pieces of cutting steel. These bits are held firmly in position by means of a mortised bolt which passes through the flange. These straight knives are intended to cut down the square edge of the grooved side and the square shoulders of the tongue side. Between the straight knives and diametrically opposite each other are arranged two small circular bits set into the flange of this section of the head so as to follow each other in the cutting of the lower portion of the tongue or groove. Between the other quarters of the straight knives the solid portion of this section is cut away and the second section, which slides over the solid central hub, has projections or lugs fitting into these openings. On these projections are two other small circular bits. These bits are capable of being adjusted by means of the expansion feature, which is controlled by an automatically locking expansion ring and assures a uniform size of tongue and groove.

As may be seen from the illustrations, this head has a perfect running balance and it is capable of turning out absolutely accurate work at an extremely rapid rate. It has been developed and is being built by Samuel J. Shimer & Sons, Milton, Pa.

VENTILATION OF STORAGE BATTERY HOUSES.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

In connection with the electrification scheme of the New York Central terminal in New York there has been installed as part of the substation equipment, several large storage battery houses. The companies furnishing the batteries were willing to give a ten years' guarantee, provided the temperature of the battery house was maintained at 70 degs. This, of course, necessitated a heating plant for cold weather and a means of cooling in warm weather, as well as good ventilation at all times.

In considering the subject it was found that the charging of the batteries caused the discharge of destructive acid fumes, which would attack and destroy iron piping. This prevented the possible use of a direct system of radiation and made it necessary to adopt the blower system. The use of this system was also advisable because of the positive ventilation which it would afford.

The entire heating plant, for each battery house, is centralized in a detached building and the heated or cooled air is distributed to various portions of the house through ducts, which are protected in such a manner as to prevent the corrosive action of the acid fumes. The air is circulated through a section pipe heater, which can be used for cooling as well, by means of a steel plate fan driven by a belted motor. Steam for heating is supplied by a small boiler.

INTERIOR OF BATTERY HOUSE AT KINGSBRIDGE SUBSTATION—NEW YORK CENTRAL.

Two methods of distribution have been employed, one, used at the Yonkers power station, providing several inlets to various parts of the battery room, and the other, used at the other stations, having but one large inlet at the end of the room. The latter system has been found to be as satisfactory as the former and in view of its simplicity and lower cost will probably be used in all later stations.

These heating and ventilating systems were designed by the American Blower Company of Detroit, Mich., and its apparatus is used throughout.

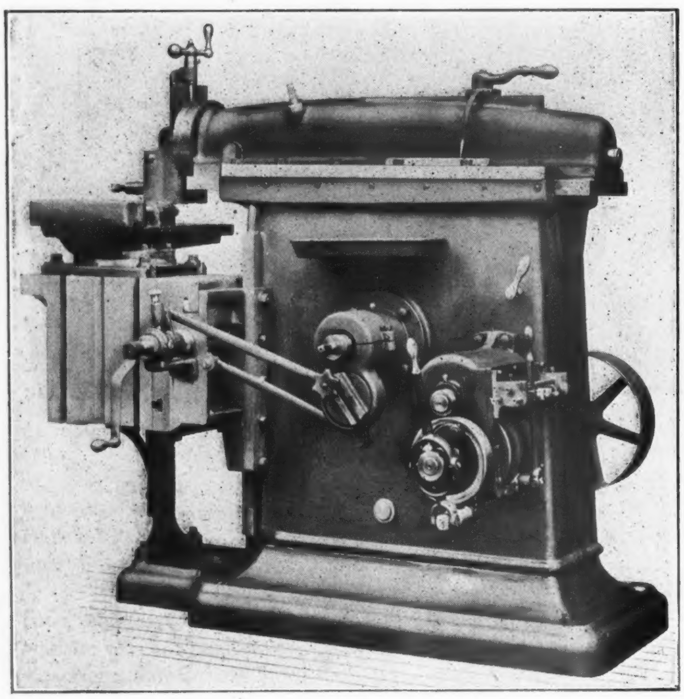
The Board of Trade reports that the Shrewsbury wreck of the London and Northwestern, October 15, 1907, when 16 persons were killed, was caused by the engineer falling asleep.

IMPROVED GEAR BOX FOR SHAPERS.

The gear box, shown in the illustration as applied to a 20 inch back geared crank shaper, is a new design of The Queen City Machine Tool Company, Cincinnati, O. It furnishes four speeds; the design is simple and the construction substantial and durable. It is easy to operate and is not at all clumsy, either in appearance or operation. Gear boxes in automobile construction have probably been developed to a more advanced stage than for any other use and it is said that the design of this new gear box is similar, in many respects, to some of the latest types used in automobile construction.

As may be seen from the drawing, the driving pulley is attached to one end of the shaft which passes through the shaper and forms the main shaft in the gear box. On this shaft is a long sleeve which has mounted on it four gears inside of the box, and the ring of the clutch on the outside. When the clutch is engaged the sleeve is driven by the shaft; when it is disengaged the sleeve revolves slowly, due to friction, unless some of the gears on it are engaged with the intermediate shaft, when it remains stationary. On the intermediate shaft are mounted four sliding gears arranged in two pairs. By means of the device shown in the upper right hand corner of the drawing, any one of these four gears may be engaged with a corresponding gear on the driving sleeve and locked in that position.

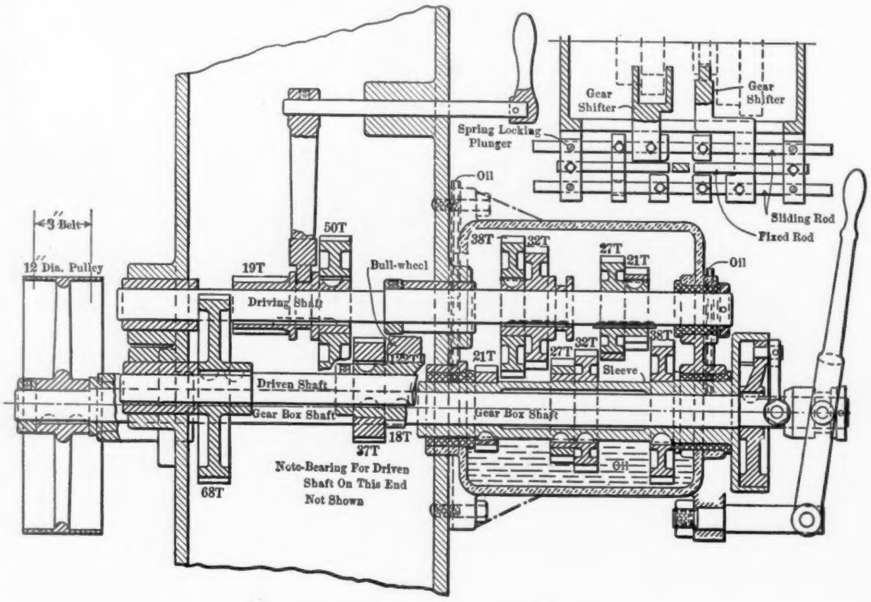
As has been stated, the sleeve rotates slowly when not engaged and no trouble is encountered in slipping the gears into mesh. It is said that the four gear box changes can be made in four seconds. This is remarkable as the expanding clutch and all of the gears are each time automatically, securely and



QUEEN CITY SHAPER WITH GEAR BOX.

independently locked in all the different working and idle positions. The drawing shows all of the gears disengaged and it will be seen that the length inside of the box is very little greater than the combined width of the faces of all the gears. The floor space required by the machine equipped with the gear box is not greater than when the cone belt drive is used.

The gear box combined with the back gear arrangement, which is shown on the drawing, provides eight speeds, which give cutting strokes per minute as follows: 7.2; 10.9; 15.4; 23.5; 34.8; 53.1; 74.7; 114. The index plate aids in choosing the proper speeds. The gear box proper, in addition to being bolted to the column, has a press fit in the column. The different parts of the box are easily accessible for inspection without removing it



DETAILS OF GEAR BOX FOR SHAPERS.

from the column. As with the regular machines, the back gears are operated by the handle, shown above the gear box, which is pushed in or pulled out according to the speed required. The arrangements for oiling the various parts are clearly shown in the drawing.

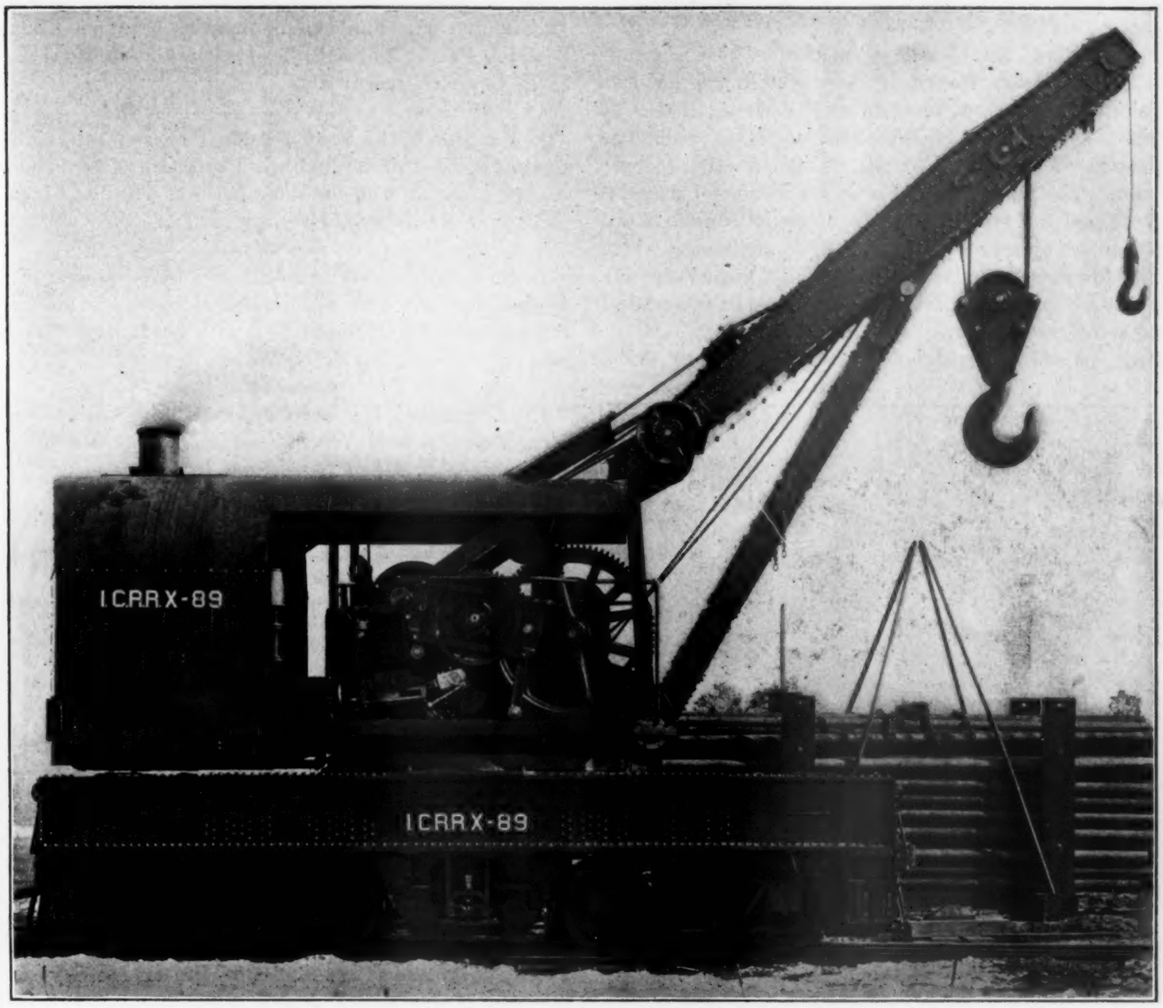
RAILROAD EARNINGS.

The reports of railroad earnings to the Interstate Commerce Commission do not admit of a comparison with the earnings of previous years, but they are now beginning to be useful as a means of studying developments in the business of transportation for a number of months past. Gross and net earnings of practically all the railroads in the country, by months, from July 1 to December 31, are now available, and the figures for January cover the earnings of 183,400 miles of road out of a total of something over 224,000 miles.

For the sake of accurate comparison the earnings have been reduced in the subjoined table to a per mile basis. The January figures are affected more or less by the fact that approximately 19 per cent. of the total mileage of the country is not included, but the portion included is so substantial that the gross and net earnings per mile are probably not far from what the complete figures will show. The net figures represent operating income after taxes have been deducted. The operating ratio represents the proportion of strictly operating expenses, exclusive of taxes, to gross earnings:

	Gross.	Net.	Op. ratio.
January	$770	$153	76.4
December	863	198	73.5
November	983	262	70.1
October	1,117	339	66.8
September	1,043	314	67.0
August	1,079	345	65.2
July	1,022	304	67.2

Gross earnings reached their maximum in October, but net earnings were not at their highest in that month, having been $6 per mile or a little less than 2 per cent. under the net returns of August. Taking the October earnings to represent the high tide of railroad prosperity the falling off in three months, as shown by the January figures, was 31 per cent. in gross earnings and 55 per cent. in net earnings after taxes. The successive operating ratios indicate how slow the railroads were to reduce expenses proportionately to the loss of business.—*Wall Street Journal.*



ICO TON WRECKING CRANE OF NEW DESIGN—ILLINOIS CENTRAL RAILROAD.

A ONE HUNDRED TON WRECKING CRANE.

ILLINOIS CENTRAL RAILROAD.

The Illinois Central Railroad has recently received a wrecking crane, built by the Shaw Electric Crane Company of Muskegon, Mich., which incorporates many new features. This crane has a capacity of 100 net tons at a 17 ft. radius, 80 tons at a 20 ft. radius and 60 tons at a 23 ft. radius, all obtained by the main hoist. In addition there is an auxiliary hoist which has a capacity of 40 tons at a 30 ft. radius, using two cables and a sheave block, and 20 tons at a 32 ft. radius with a single cable.

An important feature in the design, and one which makes possible several improvements over past practice, is the location and the position of the engines, which are reversed from the usual arrangment and have the cylinders toward the rear. This makes the piping short and direct and keeps it away from the machinery and from obstructing the engineer's passage. The main steam pipe branches at the throttle and passes downward at either side to the engine cylinders. The exhaust pipes pass underneath and are carried to a separator mounted on the back of the boiler, where the water in the exhaust steam is drawn off. The steam is then exhausted through pipes in the boiler and discharged into the stack immediately above the upper tube sheet, thus going through the whole height of the stack and giving excellent draft. This arrangement of pipes places them entirely out of the way and removes them from being subjected to strains or vibrations coming on the frame work of the crane. The keeping of the steam work to the rear in this manner makes it possible to put the side frames farther apart and keep the machinery low, resulting in a lower center of gravity and a better view from the operating platform.

The engines have an improved Walschaert valve gear, which gives a smooth action at all speeds and is easily reversed under load. The boiler has a good reserve capacity and a special arrangement of tubes permits the easy cleaning of the crown sheet. A dry pipe is provided and every precaution is taken to secure dry steam under the worst conditions. The boiler is provided with a telescopic stack, shaking and dumping grates and a dumping ash pan.

The crane is self-propelling by means of gears driving on one axle of each truck. This gearing is so arranged as not to interfere with the free movement of the trucks. A friction drive is provided in the gearing on each truck, so that any inequality in diameter of drivers is readily taken care of. Since the car is driven from both trucks it will drive equally well with the load suspended at either end. Self-lubricating center and side bearings make the crane superior to most rolling stock for taking sharp curves.

The design of the jib is a departure from past practice, as can be seen in the illustration, and avoids the combined bending and compression strains of the older type and gives a lighter and stiffer structure.

Complete air brake equipment, both automatic and straight air, are provided, and complete control of the brakes by the crane operator is provided by means of a permanent pipe connection from the crane to the car in the straight air system. Arrangements are made for the use of steam in applying the main and auxiliary hoist band brakes in addition to the usual hand applying mechanism.

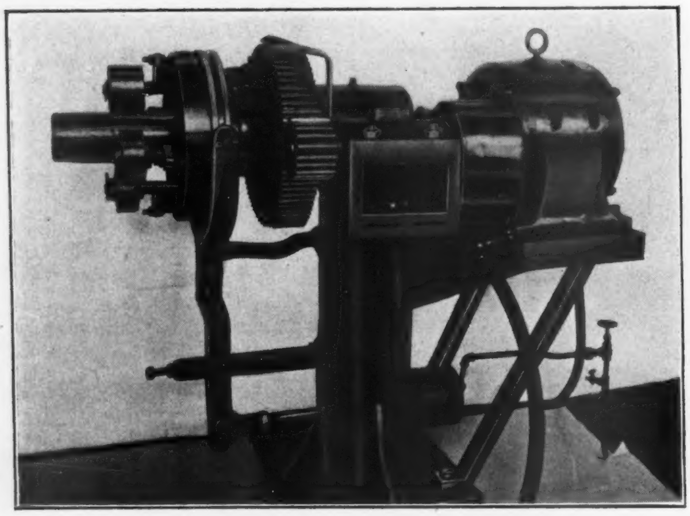
The main and auxiliary hoist parts are interchangeable practically throughout. The crane is built principally of steel, very little cast iron entering into the construction. An unobstructed passage for the engineer to and from the cab has been provided on both sides of the machine.

The total weight of the crane, not including coal and water, is approximately 106 tons. This machine was purchased through Manning, Maxwell & Moore, New York.

MOTOR DRIVEN TUBE WELDING MACHINE.

The illustration shows a tube welding machine which is standard on the Canadian Pacific Railroad, and was designed and patented by Walter Byrd, general foreman at Revelstoke, B. C. In using this tool the scarfing machine has been dispensed with. The safe end is expanded by an air machine, so that it will slip over the tube 3/16 in. The tube is pushed over the stationary mandrel on the machine and the safe end is welded on by forcing down the revolving rollers by means of a compressed air device, which is operated by the foot. The machine may be adjusted for any size tube, or gauge, and the rollers may be removed and replaced by disc cutters for cutting tubes.

The machine may be adapted for either belt or motor drive.



BYRD TUBE WELDING MACHINE.

The motor shown in the illustration is of 5 h.p. capacity, operating at 1,800 r. p. m., the rollers making 750 r. p. m. The shafts upon which the rollers are mounted pass through holes in the large ring and are pivoted to the large gear as shown. The shafts pass through the ring at a slight angle and the ring may be moved in or out, parallel to the axes of the mandrel. Both the gear and the ring revolve on water cooled centers.

By pressing a treadle with the foot air is admitted to the small cylinder at the base of the machine and the upper part of the large lever, the fork of which engages with the slot in the large ring, moves to the right, thus forcing the rollers toward the mandrel. When the tube has been rolled to gauge the foot is removed from the treadle and a spring in the cylinder brings the lever back to its former position, releasing the pressure on the rollers. The mandrel may be easily removed when necessary.

PERSONALS.

John T. Luscombe has been appointed master mechanic of the Toledo & Ohio Central Ry. at Bucyrus, Ohio.

W. J. Spearman has been appointed to the new office of master mechanic of the Idaho & Washington Northern Ry., with office at Coeur D'Alene, Idaho.

The office of R. Tawse, superintendent of motive power of the Detroit, Toledo & Ironton Ry. and the Ann Arbor R. R., has been moved from Jackson, Ohio, to Toledo.

Hugo Schaefer has been appointed master mechanic of the Panhandle division of the Atchison, Topeka & Santa Fe Ry., to succeed O. A. Fisher. Mr. Schaefer's headquarters will be at Wellington, Kan.

H. W. Watts, master car builder of the Monongahela Connecting Railroad, died on April 13 at Pittsburg, Pa., at the age of 57 years. Mr. Watts was also president of the Railway Club of Pittsburg.

W. J. Monroe has been appointed master mechanic of the Oklahoma and Panhandle divisions of the Chicago, Rock Island & Pacific Ry., with headquarters at Chickasha, Okla., vice E. E. Chrysler, resigned.

J. W. Storey has been appointed mechanical engineer of the Central of Georgia Ry., with headquarters at Savannah, Ga. Mr. Storey formerly held the same position with the Cincinnati, New Orleans & Texas Pacific Ry. at Ludlow, Ky.

F. R. Cooper, superintendent of motive power of the South Buffalo Ry., has been appointed superintendent of machinery of the Kansas City Southern Ry., with headquarters at Pittsburgh, Kan., to succeed R. M. Galbraith, resigned.

J. H. Sanford has been appointed purchasing agent of the New York, New Haven & Hartford R. R. He succeeds to the duties of A. E. Mitchell, manager of purchases and supplies, resigned. The latter title has been abolished.

G. F. Weiseckel, general foreman of the Baltimore & Ohio Ry. at Glenwood, Pa., has been appointed master mechanic of the Cumberland division to succeed A. H. Hodges, resigned. Mr. Weiseckel's headquarters will be at Cumberland, Md.

D. R. MacBain, assistant superintendent of motive power of the Michigan Central R. R. at Detroit, Mich., has been appointed assistant superintendent of motive power of the New York Central & Hudson River R. R., with headquarters at Albany, N. Y.

THE COAL INDUSTRY IN 1907.—A production of between 450,000,000 and 460,000,000 net tons of coal in the United States in 1907 is indicated by the returns received thus far by the United States Geological Survey, or an increase of about 10 per cent. over the record breaking output of 1906, according to E. W. Parker, coal expert and chief statistician of the survey. The most notable increase was made in the production of Pennsylvania anthracite, in which a gain of over 20 per cent. was recorded. The shipments of anthracite in 1907 amounted to 67,109,393 gross tons, as against 55,696,595 gross tons in 1906. This would indicate a total production for the year of approximately 76,366,000 gross tons, or about 85,840,000 net tons.

BOOK NOTES.

Locomotive Break Downs. By Geo. L. Fowler. Revised and enlarged by W. W. Wood. 266 pages. 4½ x 6¾. Flexible covers. Illustrated. Published by the Norman W. Henley Publishing Co., 132 Nassau St., New York. Price, $1.00.

This book, which is arranged in catechism form, covers very fully all possible accidents to locomotives and their appliances. The earlier editions, which are well known to most enginemen, have been completely revised and in addition to features concerning the Walschaert valve gear and electric head lights, much new matter in connection with air brakes, has been added. It is carefully illustrated with line drawings, which clearly explain the methods suggested for making repairs. The index has been made very complete and in cases of emergency will permit the rapid examination of the procedure recommended. A book of this kind is practically indispensable to young runners.

Method for Earthwork Computations. By C. W. Crockett, Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute. Cloth; 114 pages; 5¾ x 9. Illustrated. Published by John Wiley & Sons, 43 E. 19th St., New York. Price $1.50.

An attempt has been made in this book to formulate a series of rules by which the terms necessary for the numerical computation of earthwork volumes, either by the prismoidal formula or by the average end area method, may be written directly from the notes. The author has prepared a slide rule, which is described in chapter six of the book, that may be used for all earth work determination. The arrangement of the scales on this

rule are such as to make the instrument very general in application. The work is most completely illustrated and excellently arranged.

Locomotive Catechism. By Robert Grimshaw. 27th Edition. Revised and enlarged. 817 pages. 4¾ x 7¼. Cloth. Illustrated. Published by the Norman W. Henley Publishing Co., 132 Nassau St., New York. Price, $2.50.

This edition of the well known catechism has been so thoroughly revised that it may be said to be practically a new work. It has been greatly enlarged and the matter has been more conveniently arranged. It contains nearly 4,000 questions and answers in connection with the design, construction, repair and running of all kinds of locomotives, which are accompanied by 437 illustrations. The work is intended as a preparation for examination and the instruction of engineers, firemen, trainmen, switchmen, shop and roundhouse men. All of the very latest features in locomotive construction have been considered.

Manual of Recommended Practice for Railway Engineering and Maintenance of Way. Cloth. 6 x 9. 290 pages. Illustrated. Published by the American Railway Engineering & Maintenance of Way Association, 962 Monadnock Block, Chicago. Price, $3.00.

This book contains the definitions, specifications and principles of practice adopted and recommended by the American Railway Engineering & Maintenance of Way Association and consists of a compilation of recommendations on the various subjects which have been most carefully discussed and finally voted upon by the association. The work has been handled by sixteen different committees, dealing with the following subjects: roadway, ballasting; ties; rail; track; buildings; wooden bridges and trestles; masonry; signs, fences, crossings and cattle-guards; signaling and interlocking; records, reports and accounts; uniform rules; organization, titles, codes, etc.; water service; yards; terminals; iron and steel structures and classification of track. The last edition has been revised down to the end of 1907.

Engineering Index Annual for 1907. Cloth; 434 pages; 6½ x 9½. Published by the Engineering Magazine, 140 Nassau St., New York. Price $2.00.

The compiling of an index of all technical and scientific articles of importance, which have appeared during the year in technical papers of all countries, and incorporating it in one volume, is a scheme which is most thoroughly appreciated by all engineers and others who have occasion to look up information on technical subjects. This yearly volume is taken from the index published monthly in the Engineering Magazine and in order to make it commercially practical and of a reasonable price, the same scheme of classification is followed as is used in the monthly parts. It has been found that this annual form of index has a large advantage over five-year volumes, both to the consultant and the publishers, since it indexes current literature which is timely and fresh and easily procurable if desired. In the 1907 volume the details of the classification have been slightly modified and improved, special efforts being made to standardize catch words, and cross referencing has been introduced on a larger scale than in the preceding number.

Power and Power Transmission. By E. W. Kerr, Professor of Mechanical Engineering, Louisiana State University. Second edition. Revised. Cloth; 366 pages; 5¾ x 9. Published by John Wiley & Sons, 43 East 19th St., New York. Price $2.00.

The first edition of this work, which appeared in 1902, has been improved by the re-writing of the chapters on steam turbines and valve diagrams, and by the addition of several pages of matter upon the subject of heat and the use of the steam table. A new steam table has replaced the one in the earlier edition. A large number of problems have also been added, and the whole work thoroughly revised. It forms a treatise on power and power transmission, dealing with the elementary principles of these subjects. It is not intended as an exhaustive treatment in any respect, but will be found to be of great value in giving the guiding principles for a more thorough investigation. Examples are given at the end of each chapter for the purpose of fixing in the mind of the student the more important principles contained therein. Many of these examples are from practice. It is divided into three general parts. The first dealing with machinery and mechanics; the second with steam engines, valve gears and turbines, and the third with pumps, gas engines, water power and compressed air. The whole work is very comprehensive and is thoroughly illustrated.

Profit Making in Shop and Factory Management. By Charles U. Carpenter. Published by The Engineering Magazine, 140 Nassau St., New York. 1908. 6 x 9 in. Cloth. 146 pages. Price $2.00.

While this treatise was prepared with the needs of a manufacturing plant in view there is much in it which may be applied to railroad repair shops with excellent results. The book is in main a reprint of articles which appeared in The Engineering Magazine last year. These have been revised and enlarged and re-arranged for more immediate effectiveness. A superintendent of motive power of a railroad, whose shops are considered among the best managed in the country, spoke of these articles, when they first appeared, as being of great value in helping him to improve the shop organization and increase the production.

The contents of the book by chapters is as as follows: Reorganization of a run-down concern; practical working of the committee system; reports, their necessity and their uses; designing and drafting department; the tool room, the heart of the shop; minimizing the time of machine-tool operations; possibilities attending the use of high-speed steel; determination of standard times for machining operation; standard times for handling the work; standard times for assembling; stimulating production by the wage system; stock and cost systems as a factor in profit making; upbuilding of a selling organization; effective organization in the executive department.

Mr. Carpenter is president of the Herring-Hall-Marvin Safe Company and the methods described in the book are those which he found most successful in the re-organization of that company, and as superintendent of production in other large manufacturing plants, including the National Cash Register Company.

The Elements of Railroad Engineering. By Wm. G. Raymond, C.E., LL.D. 405 pages. 6 x 9. Bound in cloth. Illustrated. Published by John Wiley & Sons, New York. Price, $3.50.

This work describes the physical properties of a railroad and gives the underlying principles of their design. The policy adopted in the preparation of the work has been to treat briefly and generally those subjects which are fully covered in special volumes, to which reference is made, and to go into details in those subjects treated only in books of this kind. The plan of the book is of first describing the thing and then discussing its design. It is divided into three parts. The first, which follows a very comprehensive introduction, is on the subject of permanent way, dealing with the theory and design of all parts of this subject. The second part is on the locomotive and its work. This does not go into the design of the locomotive except in so far as it affects the design of the track. It gives the procedure for determining the features of a locomotive in connection with speed and grade problems, as well as the effect of grades and curves, number of trains, tonnage, etc. This section of the book will be found to be as interesting and valuable to the mechanical engineer as to the civil. Part III. is on the subject of railroad location, construction and preliminary surveys. An appendix of 62 pages, consisting of the reprint of a paper by Mr. W. D. Taylor, with part of the discussion thereon, which gives in detail the location of the Knoxville, LaFollette & Jellico Railroad of the Louisville & Nashville System, is included. This paper is given as an example from practice of the more important principles discussed in the book. While this book has been designed primarily as a text-book, it will be found to be most convenient for reference. It forms Volume II. of a series by this author, the others now being in the course of preparation.

Automatic Block Signals and Signal Circuits. By Ralph Scott. 6 x 8. Cloth. 243 pages. Illustrated. Published by the McGraw Publishing Co., New York. Price, $2.50.

American practice in the installation and maintenance of signals electrically controlled and operated by electric or other power, together with descriptions of the accessories now regarded as standard, is set forth in a very clear and interesting manner in this book. While it is primarily intended for the signal and railway engineers, it is written in such form as to be of interest to the layman or railway man who is not versed in the work of this department. It is profusely illustrated with diagrams and half-tone illustrations, which serve to make the text matter easily comprehended by such readers.

The Strength of Chain Links. By G. A. Goodenough and L. E. Moore. Bulletin No. 18, Engineering Experiment Station, University of Illinois. Paper; 6 x 9; 73 pages. Illustrated. May be obtained by request from the Director of the Engineering Experiment Station, Urbana, Ill.

This bulletin gives the results of a series of experiments on chain links and circular rings, which covered a period of two years, and were made for the purpose of confirming or disproving the theoretical analysis of the stresses in links and rings. The results are a complete confirmation of the analysis. The bending moments and maximum stresses for links of various forms are calculated and the results of the calculations are given in the bulletin. It contains four appendixes, giving in full the theoretical discussion which was the basis of the experimental work. This bulletin will be found to be of special interest to all engineers and manufacturers who are concerned in any way with hoisting and power transmission.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

General Electric Company.—Among the recent bulletins issued by this company are No. 4570, which illustrates and describes the new Tungsten lamps for 100 and 125 volt circuits, and No. 4573, quite an elaborate publication on the subject of lightning arresters, of which many different types are illustrated and described.

B. F. Sturtevant Co.—Bulletin No. 153 of the Sturtevant Engineering Series has recently been issued. It contains a reprint of an article from the *Engineering Magazine* of January, 1908, bearing the caption "There is Nothing New—Not Even in Fans." This article briefly traces the development of the fan blower from the time Mr. Sturtevant introduced his first fan fifty years ago.

Staybolts, Their Use and Abuse—The Falls Hollow Staybolt Company, Cuyahoga Falls, O., is issuing a small book containing an article on the above subject by Mr. John Hickey, which is based on a long experience in active railroad work, and draws attention to many features, which are generally overlooked by master mechanics and others, in the matter of proper design and maintenance of staybolts.

Flexible Shaft.—The Coates Clipper Mfg. Co., Worcester, Mass., is issuing a catalog describing its hardened steel, ball and socket joint, flexible shaft, which is claimed to have many advantages over the wire cable flexible shaft. It gives a solid steady drive throughout its entire length and is capable of transmitting as much power backwards as forwards. The illustrations in the catalogue show the great variety of places where a shaft of this type can be used to advantage.

Sterling Lubricators.—The Sterling Lubricator Company, Rochester, N. Y., is issuing a small catalog, which fully describes and illustrates several designs and arrangements of force feed lubricators. These lubricators can be furnished with any number of feed pipes and in practically any capacity of reservoir. They are all automatic and capable of very delicate adjustment, each feed being separately adjustable. The construction is such as to give a much smaller drop than usual, which permits a much more regular and positive lubrication with a smaller amount of oil.

Champion Power Hammer.—Beaudry & Co., 141 Milk St., Boston, Mass., is issuing a small leaflet describing the Beaudry Champion hammer, which is built in sizes from 50 to 500 lbs. weight of ram, and is adapted for all kinds of forgings. The foremost claims made for this hammer are superior elasticity and perfect control of the force of the blow struck by it. These are obtained by a new device which is very simple and direct acting. The leaflet fully describes the construction of the hammer and contains a table of dimensions, weights and prices.

Jeffrey Mine Equipment.—The Jeffrey Mfg. Co., Columbus, O., is issuing a leaflet, largely given up to illustrations, which shows fourteen Jeffrey specialties of special interest to mining engineers.

Welding Pipes and Rods.—The Goldschmidt Thermit Company, 90 West street, New York, is issuing a leaflet illustrating and describing the apparatus and process for satisfactorily butt-welding tubes and rods by the use of thermit. The equipment shown is arranged for welding either horizontal or vertical pipes and is suitable for use in very close quarters.

Corrugated Fire Boxes and Flexible Tube Plates.—William H. Wood, Engineer, Media, Pa., is issuing a catalog descriptive of his design of locomotive fire boxes and tube plates, which provide perfect flexibility and allow expansion in all directions without putting unnecessary strains at the joints and ends of the tubes. The corrugated type of fire box gives an increased amount of heating surface, fewer staybolts and a large reduction in trouble with leaky joints and mud rings. The illustrations give working drawings of these fire boxes, which are now being applied on several railroads.

Engine Lathes.—The 1908 edition of The Lodge & Shipley Machine Tool Company, Cincinnati, Ohio, catalog, is considerably larger and more complete than its predecessors. Their well known patented headstock is clearly described with the aid of well-chosen illustrations, as is also the cone headstock. The tailstock and bed, carriage and apron, and screw cutting and feeds are described in detail with both half-tones and line drawings. Specifications are given for the various sizes of both the patent head and cone headstock engine lathes. Several pages are devoted to a consideration of individual motor drives; also to turrets and accessories which the company is prepared to furnish with its lathes.

NOTES

S. Obermayer Company.—Mr. J. E. Evans, for the past twenty years Chicago representative of the above company, was elected alderman of his ward at the last election held in that city.

American Locomotive Company.—The general offices of the above company were removed on April 24, 1908, from 111 Broadway to the Cortlandt Building, 30 Church street, New York.

American Steam Gauge & Valve Mfg. Co.—Mr. E. H. Webster, who has had several years' experience in mechanical lines, has accepted a position with the above company and will make his headquarters at its Chicago office.

Westinghouse Electric and Manufacturing Co.—The executive, sales and export offices of the above company formerly located at 111 Broadway and 11 Pine street, New York, were removed to the new City Investing Building, 165 Broadway, on April 20, 1908.

Falls Hollow Staybolt Company.—The staybolts to be used in the thirty locomotives for the Paris-Orleans Railway of France, now being built by the American Locomotive Company, will be made from hollow staybolt iron furnished by the above company.

Westinghouse Machine Company.—Mr. E. E. Keller, for over twenty years connected with the Westinghouse interests, and for fourteen years vice-president of the Westinghouse Machine Company, having completed his duties as receiver and general manager, has severed his connection with the management of that company and will take a much needed rest.

Machine Sales Co.—Mr. P. R. Brooks has been appointed general manager of the above company, with a business address at 68 William street, New York. This company has a large and exceptionally well equipped manufacturing plant at Peabody, Mass., where it is prepared to build presses, machine tools, gas engines and special machinery of all kinds from specifications.

Quincy-Manchester-Sargent Company.—This company has decided to discontinue the manufacture of the line of pneumatic compression riveters which it acquired at the time of the purchase of the Pedrick & Ayer Co., and has disposed of this part of its product to the Hanna Engineering Company of Chicago, who will improve the machines and be in a position to furnish repair parts for all riveters that have been sold in the past. The discontinuing of the manufacturing of this line will permit the company to devote more attention to its metal sawing machines, cranes and hoists and car steps.

Locomotives—New York Central Lines.—The order of 136 locomotives received by the American Locomotive Company from the New York Central Lines, is to be composed of the following different types. For service on the New York Central & Hudson River Railroad, 20 Pacific type, 22 x 28 in. cylinders; 45 consolidation type, 23 x 32 in. cylinders, and 29 six-wheel switching type, 21 x 28 in. cylinders. For the Boston & Albany Division, 12 Pacific type: 20 consolidation type, and 10 six-wheel switching, having the same size cylinders as above. In addition to these steam locomotives this company has also received an order for twelve electric locomotives from the New York Central.

A PRACTICAL DRAWING OFFICE SYSTEM

Canadian Pacific Railway.

By G. I. Evans, Chief Draughtsman.

SYNOPSIS.

The efficiency of the drawing office system of a manufacturing plant building modern machinery is reflected, to a large extent, by increased production and decreased cost, which is made possible by economical design and careful attention to standardization. Under present conditions of railroading in America, it is evident that railroads which are building part of their equipment, or even keeping it in repair at shops of their own, are on a plane with a manufacturing plant, and that standardization, which can best be handled by the drawing office, is the most important issue in the motive power department.

To be in a position to handle this work intelligently, a very necessary part of the drawing office equipment is a complete set of records of all rolling stock and other equipment, which, by means of some practical system of indexing and filing, must be readily accessible. These records must be kept up to date with the improvements and additions which are constantly being made. Besides this, it is necessary that a large amount of information, in convenient form, be placed at the disposal of motive power officials at distant points, which will keep them thoroughly posted as to repair parts, standards which have been adopted, regulations governing the performance of certain duties, such as testing boilers, etc., and a number of other subjects. The system at present in use in the motive power drawing office of the Canadian Pacific Railway has been evolved to fill these requirements, and is as follows:

Drawing Tables.—The office equipment is arranged, as far as possible, with a view of dividing the work under different leading, or elevation draughtsmen, who lay out, direct and check the work of the detail men; the disposal of the drawing tables is then, naturally, in the direction of keeping the detail men near the leading draughtsman. This can conveniently be arranged by means of double tables at which the men face each other, and for this reason the three-man table, shown in Fig. 1, has been adopted, the leading man occupying one side which has a surface of 100 x 38 in., the other side, which is 100 x 30 in., being divided between the two detail men. Three instrument drawers are provided, and one large drawer on the leading man's side for holding reference work; the tables are also fitted with slides, arranged to pull out from underneath the tops, and a large shelf underneath the body of the table which is used for holding reference drawings during working hours. Besides these a small reference table is also used, as shown in Fig. 2.

No drawing boards are used, the tops of the tables being inclined about 1 in 6, the height at the front being 36½ in., which represents average conditions. T squares are also dispensed with, a straight edge 30 in. long and two large triangles being used for laying down base lines; this system is somewhat faster and is much less cumbersome than where a very long and heavy T square is used.

Drawing Paper for Elevations.—Elevation drawings of locomotives, cars and other large equipment are made to a scale of 1½ in. to the foot, on cloth-backed elevation sheets which are manufactured to specifications and are rigidly inspected before acceptance. These sheets are purchased in two sizes, 26 x 75 in., which is used for the largest elevations, such as 4-6-2 type locomotives, and 26 x 66 in., which is used for ordinary elevations. One of the requirements is that the sheets be supplied in a flat condition, which is very important, as they are not tacked down to the tables, but are simply laid on them. The drawing, when completed, will show practically all parts of the locomotive, or other appliance, and is filed as part of the office record after a tracing, which shows all parts necessary for issue to the shops, has been made from it.

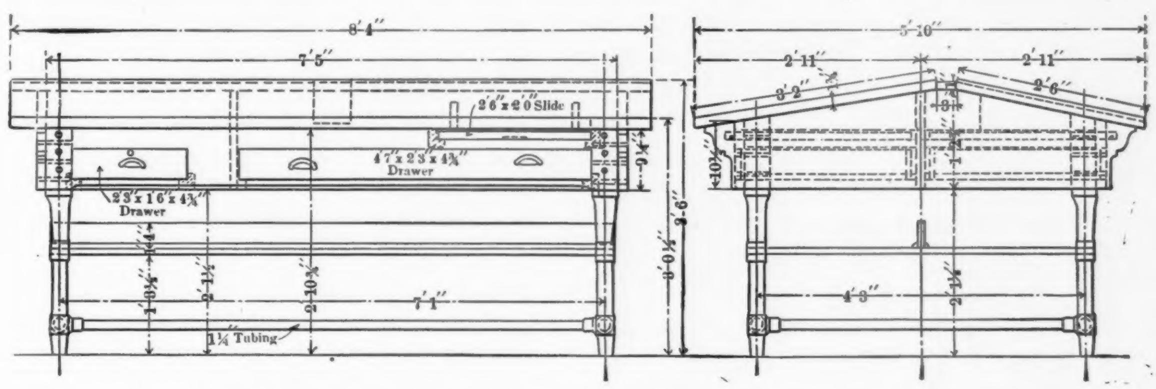


FIG. 1.—DRAWING TABLE FOR A LEADING DRAFTSMAN AND TWO DETAIL MEN.

Filing System.—The fundamental principle of the system adopted is that of dividing all equipment, of which records are kept, into distinct classes, each of which is designated by a classification letter as follows:

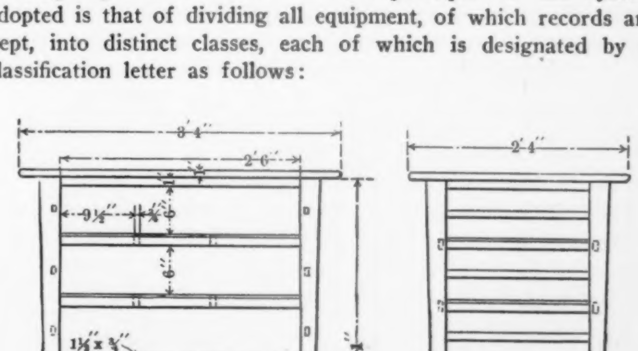


FIG. 2.—SMALL TABLE FOR REFERENCE DRAWINGS, ETC.

GROUP.	NO.	GROUP.	NO.	GROUP.	NO.
Ash Pan.	11	Front and Rear End.	44	Tool Box and Cab Seat.	75
Axle, E. & T., Crank Pin.	12	Gauge, Die, Jig, Flange Block,		Wheel, Engine and Tender.	76
Boiler.	13	etc.	45	Washout, Plugs, etc.	77
	14	Guide Bar and Yoke.	46	Whistle.	78
Boiler Details.	15	Grate.	47		
Boiler Attachments.	16	Hand Rail and Foot Step, E.			
Box, Driving, Shoe and Wedge.	17	& T.	48		
Box, Engine and Tender Truck.	18	Feed Water Attachments.	49		
Brackets, Lamp Stands, &		Lagging.	50		
Ornaments.	19	Link Motion.	51		
Brake, Engine.	20	Lubrication.	52		
Brake, Tender.	21	Miscellaneous.	53		
Brake Equipment.	22	Preliminary Designs. Wheel			
Cab.	23	Base.	54		
Cock and Valve.	24		55		
	25	Piston and Rod.	56		
Crosshead.	26	Packing, Metallic, etc.	57		
Cylinder.	27	Pipes and Fittings.	58		
Cylinder Attachments	28	Reverse Lever.	59		
Cylinder, Compound Attach-		Rocker and Box, etc.	60		
ments.	29	Running Board, and Wheel			
Cylinder, By Pass and Relief		Covers.	61		
Valve.	30	Rod, Main, Side, etc.	62		
Draw Gear, Engine.	31	Safety Valve, Steam Gauge.			
Draw Gear, Tender.	32	Steam-Heat and Special Fittings.	63		
Eccentric and Strap.	33	Steam Chest.	64		
Engine Truck, Leading and		Superheater.	65		
Trailing.	34	Signal Equipment, Lamps,			
Erecting, Engine and Tender.	35	Flags, etc.	66		
	36	Smoke Box.	67		
Exhaust and Steam Pipe.	37	Springs, Engine and Tender.	68		
Expansion Brackets. Foot Plate.	38	Spring Gear.	69		
Fire Box Fittings.	39	Tools, Engine and Tender.	70		
Fastenings. Miscellaneous.	40	Tank and Coal Bunker.	71		
Frame, Main and Front.	41	Tender Frame.	72		
Frame Details, Main.	42	Tender Truck.	73		
Fuel, Oil Burners and Details.	43	Throttle and Dry Pipe.	74		

FIG. 3.—GROUPS, OR SUBDIVISIONS, OF LOCOMOTIVE AND TENDER DRAWINGS.

C—Cars.
D—Power plants.
E—Electrical
F—Frogs, switches and track material.
H—Buildings, water tanks, coal and ash handling plants.
K—Furnaces and forges.
L—Locomotives and tenders.
R—Cranes, hoists and traversers.
T—Machines and machine foundations.
U—Office furniture.

These classes are subdivided into a large number of groups, each of which represents one or more of the details of the class in question. The number of subdivisions, of course, depends on the nature of the machine or appliance which the class represents; thus, the classification letter "L" which covers locomotives and tenders has 65 subdivisions, or groups, which are numbered consecutively from eleven to seventy-eight; each of the other classes are subdivided in a similar manner but owing to the simpler construction of the appliances and equipment represented, the number of groups is smaller.

The classification for locomotives and tenders, which has the largest number of groups, or subdivisions, is shown in Fig. 3. Each group is again subdivided to show the names of the detail

Group No.	Group Title.	Group Subdivision.
20	Brake, engine	Arrangement
		Details
		Beam
		Head and shoe
		Cylinder bracket
		Lever
		Hanger
		Rods
		Truck brake
		Details
21	Brake, tender	Arrangement
		Details
		Levers
		Beam
		Head and shoe
		Cylinder bracket
		Rods
		Hand brake
22	Brake equipment	Arrangements of valves, reservoirs, etc.
		Air reservoir, hanger and saddle
		Air pump
		Air signal
		Engineer's valve
		Brake piping
		Brake cylinder
23	Cab	Cab
		Details and furnishings
		Braces
		Corner iron
		Apron and hinge (lap plate)
		Arm rest
		Door fixtures
		Cab gong

FIG. 4.—SHOWING SUBDIVISIONS OF SOME OF THE GROUPS.

parts in it, this being desirable both for locating the group to which any particular detail belongs, and also so that the parts will always be designated by the same name throughout the system; Fig. 4 shows the subdivision of groups 20 L to 23 L. Having a complete group classification, covering every subject which may come up, the numbering of any tracing and the recording of that number becomes a simple matter. The group number and classification letter always appear on the tracing

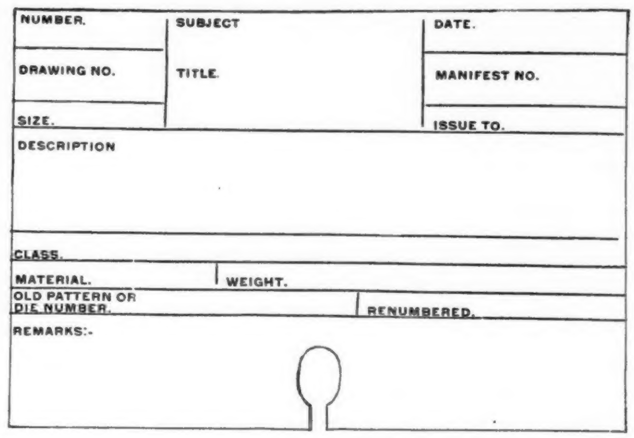


FIG. 5.—INDEX CARDS FOR DRAWINGS.

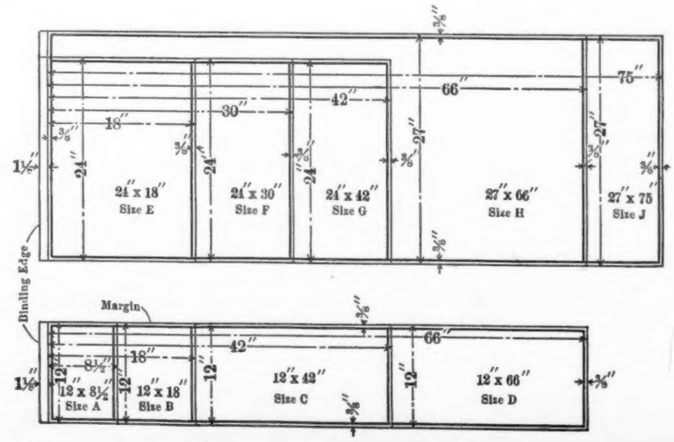


FIG. 6.—STANDARD SIZES OF TRACINGS.

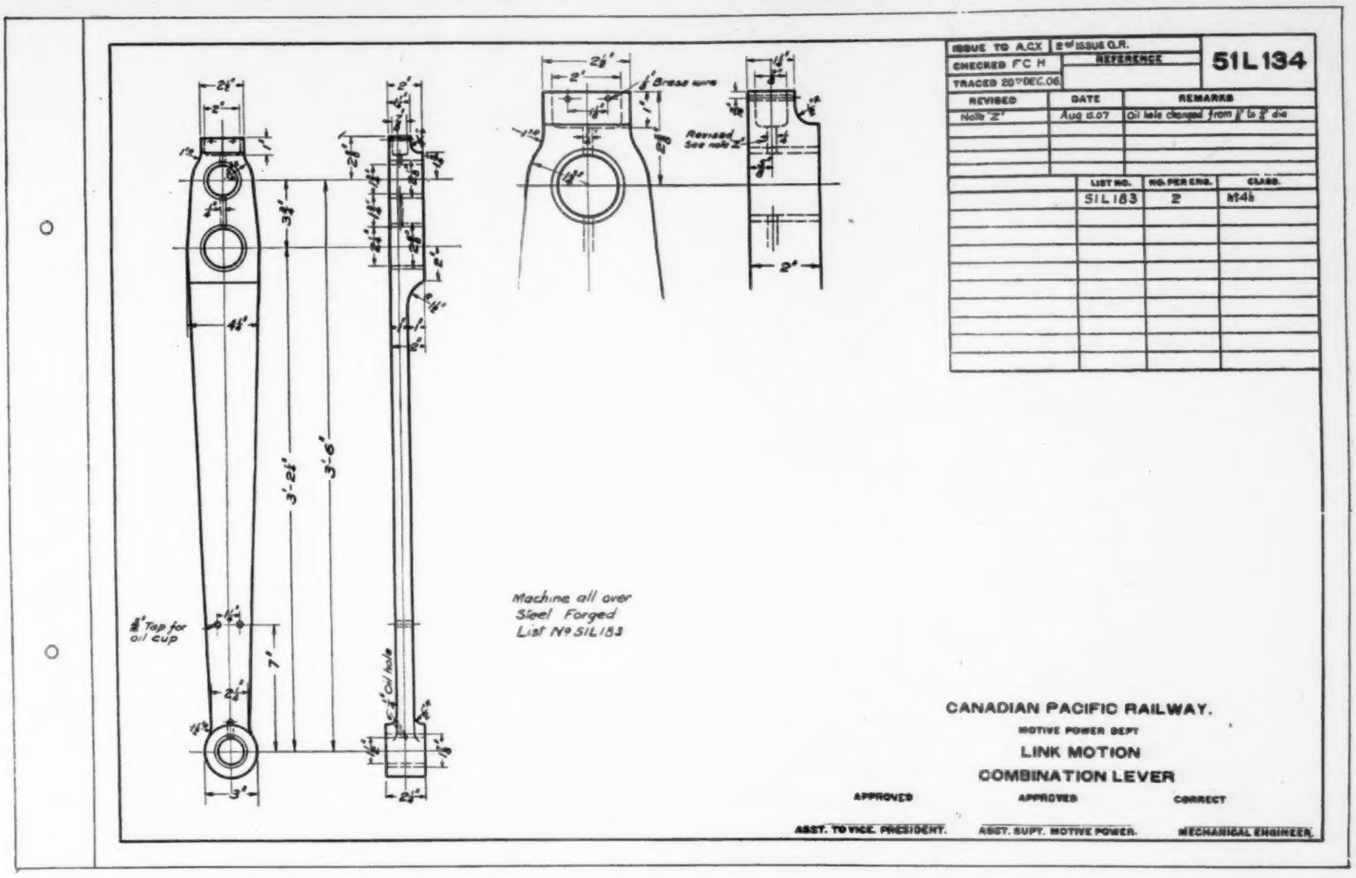


FIG. 7.—SHOWING THE ARRANGEMENT OF THE TITLE, ETC., OF ONE OF THE TRACINGS.

and form the first, or identification portion, of the number; the actual tracing numbers which run consecutively from one are written on the right of the classification letter and group number, thus, 20 L 1 represents the first engine brake drawing, 23 L 1 the first cab drawing, etc.

These numbers, with all other necessary information, are recorded on index cards, specially printed for the purpose, as shown by Fig. 5, the cards being arranged consecutively by groups in their trays, and may be readily referred to.

Sizes of Tracings.—Standard sizes for tracings vary from 12 x 18 in. for details to 27 x 75 in. for large elevations. These dimensions were determined largely by the size of the elevation drawing of a locomotive when laid down to 1½ in. scale, from which many of the more complicated parts, such as boiler, frames, etc., may be traced direct, thus avoiding the additional labor of redrawing them to a smaller scale. There is also an 8½ x 12 in. sheet which is used for pattern and other lists.

It will be seen from Fig. 6, which shows the sizes of tracings, that sheets B, C and D are 12 in. wide and sheets E, F and G are 24 in., or just twice as wide. This is so that blue prints made from sheets E, F and G may be folded once longitudinally, then inwardly so as to fit a 12 x 18 in. binder; sheets C and D are brought to this size by folding inwardly. Complete blue print sets of groups are made up in this way, both for issue and for ready reference in the office, thus saving the tracings from handling. The A size (8½ x 12 in.) is also a standard binder size.

File for Tracings.—Tracings are filed by groups in drawers, subdivided to fit the various sizes exactly, the outside of the drawer being labeled with the group number and size of the tracings contained in it.

Titles on Tracings.—A sample of the standard sheet (size B) is shown in Fig. 7. This size is used for all of the smaller details, one piece only being shown on each tracing. Titles and approvals are located in the lower right-hand corner. The third line of the title shows the name of the group to which the detail belongs, as listed in the group classification (Fig. 3). The fourth line shows the actual title or name of the part shown.

The number of the tracing, issue symbol, revision notice, and class of rolling stock or equipment on which the detail is used are shown in the upper right-hand corner. Provision is also made for tables, showing different lines, in which variation in dimensions may be entered to permit of the tracing being used for different classes of equipment, when this can be done without materially altering the outlines of the part shown. The issue symbol line is used in connection with a system for issuing blue prints to outside points and is fully described further on.

CANADIAN PACIFIC RAILWAY COMPANY
DRAWING OFFICE

PRINT REQUISITION ....190....

No....

DRAWING No.	TITLE	QUANTITY	KIND

DELIVER TO ....

....
Chief Draftsman

FIG. 8.—BLUE PRINT REQUISITION BLANK.

In case a tracing is made which supersedes some previous tracing, or if for any reason it is desirable to refer to any other record, the number of the tracing or record is filled in in the line reserved for "Reference" and forms a convenient means of identification. The revision notice column, in which is entered a short description of any change made on a tracing, has proven to be very useful, as it gives a positive record of the change and the date on which it was made. This can be done also by striking out the figures to be discarded, but this has the effect of spoiling the appearance of the tracing and may also be easily overlooked. Five lines are reserved for revisions, and

when these are filled the alterations will probably have changed the appearance of the detail to such an extent as to make a new tracing desirable.

Printing Titles.—All titles and reference headings and columns are printed in an 8 x 11 in. hand printing press, which is also used for circulars, regulations, miscellaneous forms, etc. As the amount of work done by this machine is quite extensive, and as there is also a large number of blue prints to be made daily, a small room convenient to the drawing office has been provided for this work.

To avoid delay to tracings, waiting to have titles printed on them, a schedule has been arranged by which the press will be used for this class of work between the hours of 11 and 12 A. M. and 4 and 5 P. M., at which times the tracings will be sent to the printer.

As a large amount of the work turned out in this printing office is for other departments, it became necessary to devise some means of checking the work done, and of insuring its delivery to the proper department; for this purpose the form shown in Fig. 8 is used—the tracings, circulars or forms, etc.,

CANADIAN PACIFIC RAILWAY COMPANY.

MOTIVE POWER DEPARTMENT.

SPECIFICATION No. 5 L S 1.

SPECIFICATION FOR BABBITT METAL.

No. 1 BABBITT METAL. To consist of 87 per cent. tin, 7¾ per cent. copper, 5¼ per cent. antimony, and must contain within one-half of one per cent. of the antimony specified.

No. 2 BABBITT METAL. To consist of 6½ per cent. tin, ½ per cent. copper, 14 per cent. antimony, 79 per cent. lead, and must contain within one per cent. of the antimony specified.

No. 5 BABBITT METAL. To consist of 8⅓ per cent. tin, 8⅓ per cent. antimony, 83⅓ per cent. lead, and must contain within one-half of one per cent. of the antimony specified.

No. 6 BABBITT METAL. To consist of 2 per cent. tin, 14 per cent. antimony, 84 per cent. lead, and must contain within one per cent. of the antimony specified.

No. 7 BABBITT METAL. To consist of ½ per cent. copper, 19½ per cent. antimony, 80 per cent. lead, and must contain as near as possible the exact amounts of the antimony and copper specified.

No. 8 BABBITT METAL. To consist of 5 per cent. tin, 3 per cent. antimony, 92 per cent. lead, and must contain within one-half of one per cent. of the antimony specified.

No. 9 BABBITT METAL. To consist of 40 per cent. lead, 59 per cent. copper, 1 per cent. tin.—U. S. Experimental Packing Superheater Engines.

All Babbitts must not contain more than one-quarter of one per cent. of total impurities, and must contain full amount of tin when it is specified.

Correct.	Approved.
A. W. HORSEY,	H. H. VAUGHAN,
Mechanical Engineer.	Asst. to Vice-President.

MONTREAL, AUGUST 9, 1905.

FIG. 9.—GENERAL FORM OF THE SPECIFICATION SHEETS.

which are to be printed, are handed to an order clerk who fills in the form, which is the printer's authority to proceed with the work; any explanations necessary are also noted on the slip. On completion, both prints and tracings are returned by the printer's messenger to the department owning them and the order form is returned to the clerk who checks it off.

Blue Printing.—Blue printing is done entirely by artificial light. An electric machine of the rotary type fitted with mercury tube electric lights is used. It is capable of printing 700 sq. ft. per hour, which suffices for present needs. A very convenient way of reproducing a tracing on which some revision is to be made, is as follows: A negative print on thin Vandyke (brown process) paper is first made, and if a revision is desired, the parts affected are painted out with India ink; the negative is then rendered transparent by means of a light application of paraffine applied with an electric or ordinary flat iron; a positive print is then made on Vandyke cloth from the prepared negative which gives a durable print in brown lines on a white ground. Any parts previously painted out may now be redrawn correctly on the cloth print which, if paraffined, may be blue printed in a similar manner to a tracing.

Specifications.—The group system of classification, as adopted for drawings, is also used for classifying and filing specifications, but as there is a comparatively small number of these in use at present, and very few are added, it has not been found necessary to use so many groups. The classification letters used for drawings are used for specifications and indicate the same subject. The letter "S" has, however, been added to distinguish between them. The grouping of the specifications for locomotives is as follows:

1 L S.—Specifications for building locomotives and tenders and locomotive boilers.
2 L S.—Boiler material.
3 L S.—Steel, malleable and brass castings, axles, billets, etc.
4 L S.—Electrical equipment for locomotives.
5 L S.—Babbitt and bearing metals.

These general groups cover all the necessary specifications for locomotives and tenders, other equipment being provided for in a similar manner.

The numbering is similar to that for tracings, each group being numbered consecutively, starting at one. The first locomotive building specification is thus 1 L S 1. These numbers are recorded on index cards, together with other information describing the specification. All specifications are printed on standard letter size sheets 8 x 11½ in. in the small printing press used for titles; the general form of these specifications is shown by Fig. 9.

Foreign Blue Prints.—The system of classifying and filing foreign blue prints makes use of exactly the same classifications and grouping as used for drawings, except that the letter F, indicating a file print, is added; the first foreign locomotive ashpan print filed was, therefore, numbered 11 L F 1, the first car print 11 C F 1, etc.

Under this system each foreign print filed is given a definite record number, which is plainly written on a small cardboard disc attached to it by means of a string, passed through an eyelet. The print is then rolled and placed in its proper group in a pigeon hole file, the discs bearing the record numbers being plainly visible. These numbers are recorded on index cards, arranged by group together with all other information necessary to identify the print which, when wanted, is located by referring to the proper group in the card index, and the number being obtained the print is readily found by means of the disc bearing a similar number.

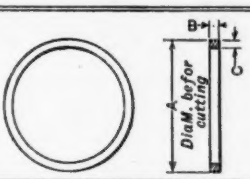
Patterns and Forgings.—The system of classifying and numbering patterns and forgings is the same as that in use for drawings; the same series of numbers is used and no attempt is made to distinguish between them; at first thought this may appear confusing but exactly the reverse is the case, it having proved one of the most simple and convenient parts of the whole system and from it has been worked out a method of listing patterns and standard material for distribution to repair shops by which replacement parts can be accurately ordered by list number; this is described and illustrated further on.

The record of patterns and these list numbers is kept in the same index as used for tracings, the same cards (Fig. 5) being used. Under the heading "Number" the pattern or list number is written; the number of the tracing on which it appears is written in the space immediately underneath headed "Drawing Number."

In the case of a card which is filled out for a tracing record only, both these spaces will show the same number, it being necessary to show consecutive numbers in the top space to insure the cards being placed properly in their trays. All the other spaces shown are not necessarily filled in; as these are combination cards certain headings apply only to tracings and *vice versa.*

By means of this classification, reference to the index card for any given pattern or list number, shows at once full informa-

PISTON RINGS



LIST NO.	CYL. DIAM.	A	B	C	LIST NO.	CYL. DIAM.	A	B	C	LIST NO.	CYL. DIAM.	A	B	C
56L201	17"	$17\frac{3}{8}$	$\frac{3}{4}$"	$\frac{9}{16}$"	56L33	$18\frac{3}{8}$"	$18\frac{3}{4}$"	$\frac{3}{4}$"	$\frac{5}{8}$"	56L65	$20\frac{1}{8}$"	$20\frac{5}{8}$"	$\frac{3}{4}$"	$\frac{5}{8}$"
56L202	"	"	$\frac{13}{16}$"	"	56L34	"	"	$\frac{13}{16}$"	"	56L66	"	"	$\frac{13}{16}$"	"
56L203	"	"	$\frac{7}{8}$"	"	56L35	"	"	$\frac{7}{8}$"	"	56L67	"	"	$\frac{7}{8}$"	"
56L204	"	"	$\frac{15}{16}$"	"	56L36	"	"	$\frac{15}{16}$"	"	56L68	"	"	$\frac{15}{16}$"	"
56L205	$17\frac{1}{8}$"	$17\frac{1}{2}$"	$\frac{3}{4}$"	"	56L37					56L69	$20\frac{1}{4}$"	$20\frac{3}{4}$"	$\frac{3}{4}$"	"
56L206	"	"	$\frac{13}{16}$"	"	56L38					56L70	"	"	$\frac{13}{16}$"	"
56L207	"	"	$\frac{7}{8}$"	"	56L39					56L71	"	"	$\frac{7}{8}$"	"
56L208	"	"	$\frac{15}{16}$"	"	56L40					56L72	"	"	$\frac{15}{16}$"	"
56L23	"	"	$\frac{7}{8}$"	"	56L55	"	"	$\frac{7}{8}$"	"	56L87	"	"	$\frac{7}{8}$"	"
56L24	"	"	$\frac{15}{16}$"	"	56L56	"	"	$\frac{15}{16}$	"	56L88	"	"	$\frac{15}{16}$"	"
56L25	$18\frac{1}{8}$"	$18\frac{1}{2}$"	$\frac{3}{4}$"	$\frac{5}{8}$"	56L57					56L89	$22\frac{1}{8}$	$22\frac{5}{8}$"	$\frac{3}{4}$"	$\frac{3}{4}$"
56L26	"	"	$\frac{13}{16}$"	"	56L58					56L90	"	"	$\frac{13}{16}$"	"
56L27	"	"	$\frac{7}{8}$"	"	56L59					56L91	"	"	$\frac{7}{8}$"	"
56L28	"	"	$\frac{15}{16}$"	"	56L60					56L92	"	"	$\frac{15}{16}$"	"
56L29	$18\frac{1}{4}$"	$18\frac{5}{8}$"	$\frac{3}{4}$"	$\frac{5}{8}$"	56L61	20"	$20\frac{1}{2}$"	$\frac{3}{4}$"	$\frac{5}{8}$"	56L93	$22\frac{1}{4}$"	$22\frac{3}{4}$"	$\frac{3}{4}$"	$\frac{3}{4}$"
56L30	"	"	$\frac{13}{16}$"	"	56L62	"	"	$\frac{13}{16}$"	"	56L94	"	"	$\frac{13}{16}$"	"
56L31	"	"	$\frac{7}{8}$"	"	56L63	"	"	$\frac{7}{8}$"	"	56L95	"	"	$\frac{7}{8}$"	"
56L32	"	"	$\frac{15}{16}$"	"	56L64	"	"	$\frac{15}{16}$"	"	56L96	"	"	$\frac{15}{16}$"	"

To order material from this list give number required and list number.

MANUFACTURED MATERIAL LIST SHEET NO. 1 GROUP 56.

FIG. 11.—A "MANUFACTURED MATERIAL" LIST.

tion about it, such as equipment to which it is applied, weight, material and the tracing number on which it is shown. This system also works well with the pattern stores, it being possible to locate a pattern almost instantly by means of its group number; it is also advantageous to have all patterns of the same kind in one rack.

One of the most important functions of a railroad drawing office is that of issuing information to the shops and motive power operating officials at distant points on the road, such as pattern and repair material lists, maintenance regulations, information regarding improvements and changes which are to be made at the division or main shops, etc. In the case of pattern and material lists, no great difficulty will be experienced in issuing them in some form or other, but to insure that they will be kept up to date, owing to additional equipment coming to the road and changes to that already in service, is a much more difficult problem; the system adopted must be one which, while placing full information in the hands of those requiring it, will also lend itself readily to adjustment and additions without undue labor and expense.

A standard pattern catalog sheet is shown in Fig. 10 and contains practically all the information necessary both as an office reference and a means of ordering repair castings. These lists are printed on 8½ x 12 in. (size A) tracing linen sheets by the 8 x 11 in. printing press, leaving only the information to be filled in. Prints are then made from them and issued to both the motive power and stores departments. Binders have been supplied to all receiving these lists and they are kept in book form, arranged by group and sheet numbers, which are shown in the lower right-hand corner.

Alterations and additions are made to this list by means of printed slips of exactly the same size as the line to be changed, but which show the alteration or addition and are pasted across the original record. The corrections are made on tracing linen, each line to be corrected being repeated ten or more times, depending on the number required; prints are then made, the lines cut apart and issued to all having books.

Manufactured Material Lists.—Lists showing repair material, such as rod knuckle pins, piston rings, axles and all other standard parts which are constantly requiring renewing, owing to wear, are gotten up and issued in much the same way as a manufacturer, making a standard article, does with his catalog, in which each piece comprising the completed article is usually designated by a number.

These standard repair parts are manufactured, and a limited amount for immediate shipment kept in stock at the Angus Shops, which is the main construction and repair plant of the Canadian Pacific Railway, material being sent from there to all parts of a system comprising over ten thousand miles of track. These "Manufactured Material" lists are made up and issued in a similar manner to the pattern catalog, each piece shown being designated by a list number which is all that need be mentioned when material is ordered, as the detail drawings showing these parts are listed in a like manner. The classification of the equip-

PATTERN CATALOGUE

C. P. RY. LOCOMOTIVE CASTINGS

LINE	DESCRIPTION AND WHERE USED	PATTERN NO.	MATERIAL	WEIGHT LBS.	WEIGHT OZ.	DRG. NO.	PATT MADE
1	CYLINDER COCK BODY-STANDARD	30L95	M.I	–	14	30L94	
2							
3							
4	CYLINDER COCK SHAFT BRACKET (ON FRAME)						
5							
6	D4e.	30L211	C.I.	8	12	30L126	X
7	D6a.	30L71	C.I.	24	9	30L172	X
8	D9ab.	30L71	C.I.	24	9	30L70	X
9	D10abcd - D11-M4-U8 R. HAND	30L53	C.I.	20	–	30L52	X
10	D10abcd - D11-M4-U8 L. HAND	30L54	C.I.	20	–	"	X
11	E5f R. HAND	30L166	C.I.	14	–	30L164	X
12	E5f L. HAND	30L167	C.I.	14	–	30L165	X
38							
39	CYLINDER COCK OPERATING HANDLE BRACK'T						
40							
41	CLea-C2a-D2a-D3bcdhj- D5b.	30L210	C.I.	4	5	30L154	X
42	D4abcd-D6bcd-E2fde-F1ab	"	"	"	"	"	X
43	D3a- ENG 820-J2ac-L2b-L4c-M1ab	"	"	"	"	"	X
44	M2ab-U2abcdef-U3ac	"	"	"	"	"	X
45							
46	D9a	30L236	C.I.	1	13	30L170	X
47							
48	D6a-D9b-D10abc-D11-E5gf-G1abcd	30L67	C.I.	1	14	30L49	X
49	G2abcd-M3-M4-U8.	"		"	"	"	X
50							

ABBREVIATIONS: C. I., CAST IRON; M.I, MALLEABLE IRON; C.S., CAST STEEL; BR., BRASS; BZ., BRONZE
X INDICATES PATTERN HAS BEEN MADE. GROUP 30 SHEET 7

FIG. 10.—PATTERN CATALOGUE SHEET.

SIDE ROD KNUCKLE PINS

LIST NO.	DESCRIPTION	CLASS
62L156	For New Work.	L3
62L157	For Repairs.	
62L158	For New Work	U2ef
62L159	For Repairs	
62L160	For New Work	L4c
62L161	For Repairs	
62L162	For New Work	C2a; D3j; D4; D5; D6bcd; E4; E5ab.
62L163	For Repairs	
62L185	For Repairs	
62L186	For New Work	D10; D11; G1; G2; M4.
62L187	For Repairs	
62L188	For New Work	L4ab
62L189	For Repairs	
62L190	For New Work	U3c
62L191	For Repairs	
62L192	For New Work	L5a; M1; M2.
62L193	For Repairs	
62L194	For New Work	E1; E2abc; J2.
62L195	For Repairs	
62L196	For New Work	L1ab.
62L197	For Repairs	
62L198	For New Work	U1a.

To order material from this list give number required and list number.

MANUFACTURED MATERIAL LIST SHEET NO 1 GROUP 62.

FIG. 12.—A "MANUFACTURED MATERIAL" LIST.

ment using the parts is also given, except in the case of material which is standard for all classes.

Representative sheets of each are shown in Figs. 11 and 12, the former showing piston rings which are made to suit both new and worn cylinders, in diameters advancing by one-eighth inch through a range which covers all sizes in use, and the latter showing the list numbers of knuckle pins which are similarly made for new and repair work for different classes of locomotives. The detail drawing of one of these pins is reproduced in Fig. 13 and shows the manner in which those for repairs are sent out, leaving only the rod fits to be finished at the division shops, where the cost is higher than at the main shop, owing to less complete facilities.

A list of this kind bound in loose-leaf book style is much more convenient and useful in the ordinary roundhouse than a set of prints; also, being arranged by group, it is practically self-indexing and contains in an easily accessible form the information necessary to order material for all sorts of running repairs.

These lists are adaptable to practically every part of a locomotive and are equally valuable both as a shop and office record, as each group listed contains in condensed form all of the details shown on hundreds of drawings, which is invaluable in lo-

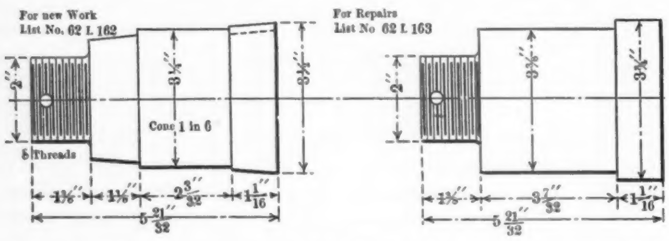


FIG. 13.—DETAIL DRAWING OF KNUCKLE PIN SHOWING DIFFERENCE IN FINISH FOR NEW AND REPAIR WORK.

cating existing patterns, and forgings for which dies have been made, in working up designs for new equipment. When these lists are being worked up, careful attention is paid to standardizing all parts possible and the number of parts which are found to differ so slightly as to be made interchangeable with some minor alteration is surprising. This is especially noticeable when working up cocks and valves, oil cups and other brass details, it being possible to sometimes cut the number of patterns carried by one-half with a resultant large decrease in the amount of repair material to be carried in stock by the stores department.

Another important advantage of this system is the ease and directness by which repair parts may be ordered from points hundreds of miles distant, either by wire or stores requisition. For example, a locomotive foreman finds that he will soon need to renew certain parts of a locomotive; he refers to his material list, locates the parts in question by means of the group numbers and places his order for the quantity, simply mentioning the list number. This does away with all confusion through different names being given to the same detail and having to turn over a lot of records to find a drawing of the part wanted, as in the case when orders are placed by means of the engine number. The order being received by the stores, the part wanted can be immediately located by its list number, if it is a stock article; if not, an order being placed on the main shop, the necessary information to do the work is forthcoming by reference to the "Manufactured Material" list which, if it does not give all the information required, refers to the drawing from which it may be obtained.

A further advantage of this system is that "New" and "Repair" parts may be listed, the former being exactly to the original size when the engine was new and the latter to correspond to a certain degree of wear, such as takes place in cylinders and pistons, rod brasses, etc. This is illustrated by the piston ring "Manufactured Material" sheet, shown in Fig. 11, on which are shown repair rings advancing in diameter by one-eighth inch and in thickness by one-sixteenth inch.

(To be continued.)

A REINFORCED FLUE SHEET.

By W. H. Lewis.*

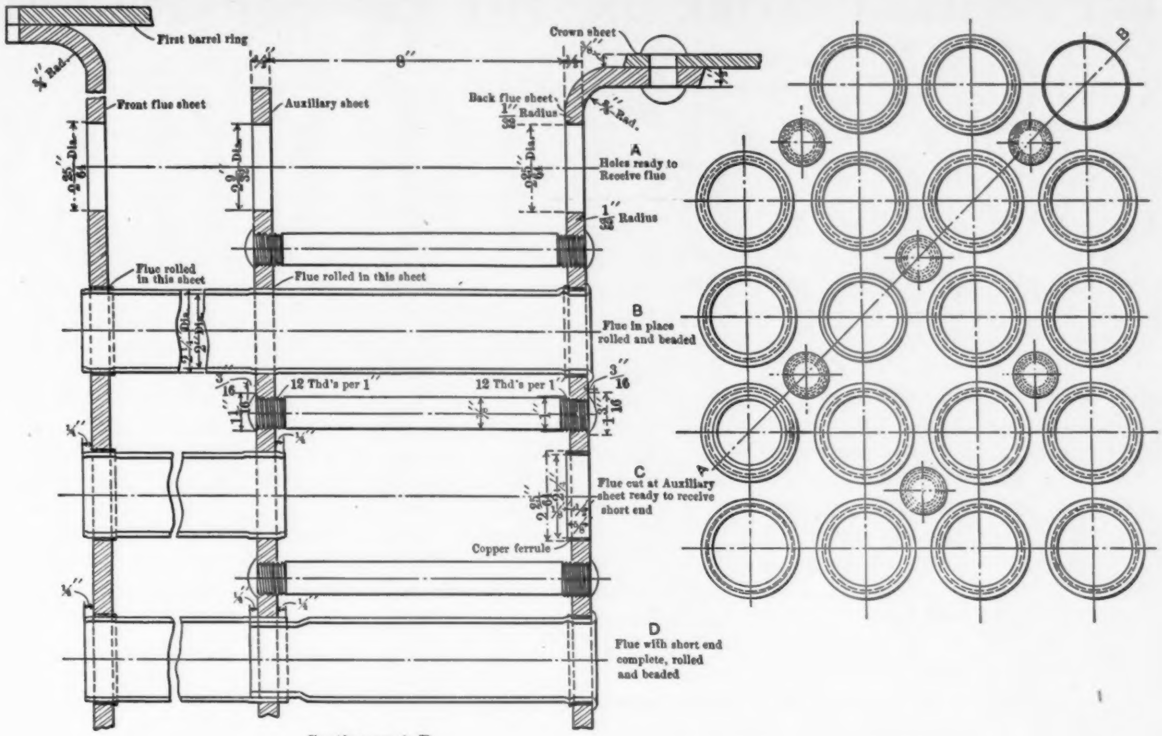
The two-part flue, as it will be termed for convenience, has a three-fold object: first, trussing or reinforcing the back flue sheet against bulging; secondly, improving the circulation in the vicinity of the back flue sheet by the formation of a channel between it and the reinforcing sheet; and thirdly, permitting the use of a detached safe end; the latter, however, when in place forming an integral part of the flue. The essential features of the apparatus are quite simple, requiring practically no alteration in the flue sheet except the additional or reinforcing sheet, approximately the same thickness or a little heavier, which is carried on staybolts 8 inches ahead of and parallel to the back flue sheet to which it is attached. In the applications so far made, the flues have been placed in vertical rows, which seems to lend itself very well to the introduction of the short spacing between staybolts holding the reinforcing sheet, but the arrangement does not necessarily preclude the diagonal spacing of the flues should that be desired.

The accompanying illustration shows the sheet as it has been attached to the firebox flue sheet of a consolidation freight engine; cylinders 21 x 30 in.; weight on drivers, 168,000 lbs.; tractive effort, 40,173 lbs.; grate area, 45 sq. ft.; firebox heating surface, 173 sq. ft.; flue heating surface, 2,778 sq. ft., and total heating surface, 2,951 sq. ft. There are 258—2¼" flues placed in vertical rows, 3⅛" pitch, which allows a bridge space between adjacent flues of ¾". In the center of the rectangle formed by every four adjacent flues, a staybolt to hold the reinforcing sheet is placed, which bolts thus form the corners of another rectangle. These bolts, therefore, are also in vertical rows 3⅛" apart the same as the flues and do not reduce the bridge between the flues, as it is customarily termed. These spacing bolts measure ⅞" at the center and are threaded at either end where they enter the back flue sheet, as well as the reinforcing sheet, and are riveted over at either end. In the earlier application these bolts were threaded into the two sheets similar to the present design and as shown in drawing, but had button heads on the fire side of the flue sheet. At the other end attaching to the reinforcing sheet the threaded portion was somewhat smaller than the body of the bolt and turned back sufficiently to provide a shoulder against which the auxiliary sheet was drawn and double nutted. But observations led to the idea that by reason of the possible retention of heat in the amount of material in the head, the life of adjacent flues was impaired; hence the adoption of the head similar to the ordinary staybolt. The same form of head has proven to be equally satisfactory where attachment is made to the reinforcing sheet. This latter sheet, swung as it is parallel to the flue sheet, necessarily has the flue holes drilled coincident with that sheet; in fact, to accomplish this, the reinforcing sheets have been bolted to the back flue sheet and the drilling done simultaneously to insure accuracy.

The body or longer portion of the flue extends from the reinforcing sheet to the front flue sheet, through each and ¼" beyond, as will be seen in the illustration. In the front flue sheet the copper ferrule has been used, but in the back sheet it has not been introduced. After this longer portion of the flue is put in place and is securely rolled in the two sheets, nothing more need be done to it. The short detached safe end, as we may properly term it, after being cut to the proper length and swaged to slip inside of the flue already rolled in the reinforcing sheet, is thoroughly annealed, then driven into place and rolled in the flue in the reinforcing sheet, making a tight telescopic joint. This is all the work that end of the safe end receives. The end entering the firebox sheet is expanded, prossered and beaded, completing the application.

The object of the reinforcing sheet, as stated, was to support the flue sheet against bulging, and in the first applications the flues were in one piece from back to front flue sheets in the customary way, but securely rolled in the reinforcing sheet through

* Superintendent of Motive Power, Norfolk and Western Railway.



Section on A-B

DETAILS OF REINFORCED FLUE SHEET—NORFOLK AND WESTERN RAILWAY.

which they passed. This anchoring of the flue in the reinforcing sheet, it was confidently thought, would act as a support for the joint and bead in the back flue sheet. There is no question but that this has been realized, as engines have been allowed to run until the beads have entirely wasted away; in fact, the end of the flue has burnt down to practically a knife edge and flush with the firebox side of the flue sheet, still holding securely and leaking but very little, if any, more than some of the flues with comparatively good beads.

It was when these engines were first handled through the shop for renewals of flues that the idea suggested itself that the flue could be cut off between the back flue sheet and the reinforcing sheet and a short end swaged, driven into and rolled, obtaining to all intents and purposes a new safe end without further disturbance to the balance of the flue reaching from the reinforcing sheet forward. In the original design it was contemplated using a detached end differing only to the extent of using a butt joint in the auxiliary sheet; the telescopic joint, however, seems to answer the purpose and fully accomplish what was intended.

The prevention of bulging of the flue sheet also seems to have been accomplished as none of the engines so far equipped have developed any indications of this trouble. Having given this additional stability to the back flue sheet, the consideration of the practicability of using a thinner flue sheet is claimed and it would seem perfectly feasible to thin the flue sheet down to at least 3/8", making the reinforcing sheet, say, 5/8" or 3/4", so as to carry the major portion of the load.

The studies of the problem would seem to show that while a great deal depends upon the initial workmanship in the application, and the material must also be given due consideration, the fact remains that the water has a powerful influence. Where there is any perceptible deposit on the flue sheet, or adjacent to the flue joint, the amount of material through which the heat must penetrate directly increases the severity and consequent destruction to the bead and flue sheet joint. Therefore by thinning down the flue sheet the conditions for retention or dissipation of the heat are in the first place improved to that extent.

The next development, and the results thus far seem very promising, is to simply roll the safe end in the back flue sheet, allowing the end of a flue to come out flush, making no attempt whatever to bead over since there is no pressure on the safe end except in the direction of collapsing. Leaving the copper ferrule out of the back flue sheet as well, would not seem to be a bad practice, although in the experiments where the beads have been left off the copper has not suffered perceptibly by exposure. It is a curious fact that in the experiments where the detached ends have been put in the same engine with, and without beads, the beads have uniformly burnt off and wasted away while those without beads, though they protrude about 1/8" beyond the face of the sheet, have not undergone any noticeable deterioration. Apparently the leaking has been largely confined to the beaded flues, which might possibly be explained by excessive working, which in the nature of things must be done cold, resulting in hardening the material, thus making it more brittle and susceptible to splitting and otherwise breaking down. To date, there are 90 engines equipped with this detached safe end, although none of them were so equipped originally, it being done as engines were handled through the shop for flue renewals. These applications have been made uniformly for the past year, and up to the present time no cases of the telescopic joint leaking have been found. This joint, therefore, proving to be entirely reliable, carries with it the freedom from whatever uncertainty has surrounded the lap or butt-welded safe end.

The flue mileage appears to show that the bead on the detached end fares the same as those on the ordinary flue; therefore, the net gain lies in the saving in time and labor in the renewal of the safe ends where the beads have worn off and wasted away, whereas it would otherwise have entailed the removal of the entire set of flues, disturbing, at no inconsiderable cost, the steam pipes in the smokebox, and draft appurtenances in order to cut and reweld the safe ends. These benefits very obviously obtain since the removal of the short detached safe ends involves simply their removal, approximating not over one-half of what it would ordinarily cost to remove the full set of flues. In bad water districts where the deposit is excessive there might be reason for the removal of the entire set of flues at shorter periods, but ordinarily the flue beads waste away before the flues should necessarily come out to be cleaned. This removal of the beaded end makes it possible to quickly overhaul the flues, restoring them to good order, very probably handling the work to an advantage in the roundhouse instead of taking the engine out of service for a longer period. In localities where the flues largely determine the mileage between shopping, it would seem perfectly feasible to maintain the flue renewals at the roundhouse, keeping the engine in practically continuous service until the machinery is completely worn out, provided the renewal of tires can also be handled at the round-house.

BETTERMENT WORK IN THE CAR DEPARTMENT.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

BY J. E. EPLER.*

Although a number of articles † have appeared in the AMERICAN ENGINEER concerning betterment methods on the Santa Fe, very little has been said concerning the details of this work in the car department. Work was started in this department in May, 1906. Some of the methods followed have been in use, to a greater or less extent, on a number of roads in this country. These were extended and followed up so as to secure the cooperation of both the men and the foremen in securing results. No changes were made until all interested were enlightened; to keep up interest each person affected was, if necessary, shown his progress daily. If minimum costs are sought, each man concerned should know what share his department is bearing and whether or not reductions are actually being made.

Past experience indicates that one of the principal reasons for expensive shop methods has been ignorance of the foremen, and even master mechanics, of the cost of operating their departments. Very few foremen know the monthly payroll of their shops. With the introduction of the clock and block systems, the timekeeping passed from the hands of the foremen to timekeepers in the master mechanic's office, or in a great many cases to the motive power accountant, and the foreman's knowledge of his payrolls ceased. Sometimes master mechanics and foremen are furnished with statements showing the total of their payrolls, but almost invariably when it is too late to make any improvement. Every master mechanic and foreman should know what each department under his jurisdiction is costing—not monthly, but daily. He should also know the amount of work accomplished for the money expended. Simple statements showing him just what has been done are often equal, if not superior to, additional help.

METHOD OF MAKING FREIGHT CAR REPAIRS.

First attempts at improvement were made in the freight car repair yards. Repair schedules were made giving standard times‡ for the various operations in repairing cars; to simplify the work required of shop inspectors and timekeepers a card was devised for keeping a record of repairs made to a car and the time required for these repairs. The face side (see illustration) is used by the yard inspector in bad ordering the car. Switchmen are notified where to place the car by the position of the card; placed vertically, the car goes to the light repair yard; horizontally, to the heavy repair yard. At this place, the main defects shown on the card give the repair yard foreman sufficient knowledge for a further placement of the car, a very important matter in heavy repairs, as repaired cars are often blocked for days and extra work is entailed by careless placing of other cars requiring heavier repairs.

When the car is placed, the time is noted and a shop inspector removes the card and gives the car a thorough inspection. He notes all defects found on the reverse side of the card (see illustration) and replaces it on the car, reverse side out. The time-

Std. Time C. R. 40.15 hr. Std. Time Carp. .... hr.

No. of Pieces	Schedule No.	DEFECTS		Standard Time
1	435	Side sill		25.
2	546	Draft timbers	B	9.
1	101	Coupler	"	1.
1	25	Buffer block	"	1.
1'	508	Side siding (sill side		.3
5'	509	Side siding " "		.75
20'	208	Side lining		.8
		TRUCKS.		
1	638	Pair wheels	B	1.2
1	590	Metal brake beam	"	.5
2	624	Brake shoes	A	.2
2	79	Bottom C-plate bolts		.4
				40.15

NAME	DATE	Time on	Time off	Time on	Time off	Total Time
G. Cokes	1/22	8	5			8
D. Miles	"	"	"			8
G. Cokes	1/23	7	6			10
D. Miles	"	"	"			10
						36

REVERSE SIDE OF BAD ORDER CAR.

keeper follows and places the time allowed by his schedule on the card. Repairmen are then assigned to the car. They sign their names and register the time in a space provided for this purpose. When the car is finished the men record the time of completion. It is then re-inspected to determine the quality of work and whether all repairs ordered on the card have been made. The O. K. time is noted, and this, together with the record of the time of placement on the repair track, has relieved many an embarrassing situation for the foreman; it forms an important part of his card record.

The card is then sent to the car foreman's office, where the

* Bonus Expert, Cleburne, Texas.

† Previous articles which have been published in this Journal concerning betterment work on the Santa Fe are as follows:

"Shop Betterment and the Individual Effort Method of Profit Sharing," by Harrington Emerson. (A reprint of a pamphlet which was prepared for distribution among the workmen on the Santa Fe.)—Feb., '06, page 61.

"Locomotive Repair Schedules," by C. J. Morrison. (A detailed description of the schedules in use at the Topeka shops.)—Sept., '06, page 338.

"The Surcharge Problem," by C. J. Morrison. (A description of the method of determining surcharges and how they are applied.)—Oct., '06, page 376. Communications concerning this article were published on page 438 of the Nov., '06, issue, and 478 of the Dec., '06 issue, Mr. Morrison going into greater detail as to the exact methods of determining the surcharge on page 479. Other communications appeared on page 64 of the Feb., '07, issue.

"Betterment Work on the Santa Fe." (A complete study of the development of this work and the general and specific results which had been obtained to date. The article covered 26 pages.)—Dec., '06, page 451. Communications concerning this article appeared in the Feb., '07, issue, page 63, and March, '07, page 102.

"Dispatching Board for Engine Repairs," by C. J. Morrison.—Apr., '07, page 131.

"Roundhouse Betterment Work," by J. F. Whitford.—June, '07, page 216.

"The Methods of Exact Measurement Applied to Individual and Shop Efficiencies at the Topeka Shops," by Harrington Emerson.—June, '07, page 221. Communications concerning this article appeared on pages 287 of the July, '07, issue, and 308 of the August issue.

"Shop Cost Systems and the Effect of Shop Schedules Upon Output and Cost of Locomotive Repairs," by A. Lovell. (A reprint of a paper presented before the Master Mechanics' Association and an abstract of the discussion. —July, '07, page 274.

"Shop Efficiency," by H. W. Jacobs. (A study of the individual and shop efficiency methods.)

"Wastes at Fuel Stations," "Reports in Connection With the Operation of Fuel Stations," and "Fuel Performance Records," on pages 134 and 140 of the April, 1908, issue, in connection with an article on "Locomotive Fuel Economy."

"General Tool System," page 239 of this issue. A description of the methods of improving the efficiency and caring for the tool equipment over the system.

"The Solution of the Crank Axle Problem," by Howard H. Lanning, page 218, this issue.

Editorial comments on the betterment work on the Santa Fe appeared on page 478 of the Dec., '06, issue; page 20 of the Jan., '07, issue, page 231 of the June, '07, issue, page 395 of the Oct., '07, issue.

‡ These standard times were determined after careful time studies, similar to those made in the locomotive department, as described in previous articles.

Form 1203 Standard.

Hall 3 08 50M 8068

Santa Fe.

Initial A. T. & S. F. Class Box Date 1/18/08.

BAD ORDER

Sent to CLEBURNE Shops. Time placed 7. a.m. 1-22 ~~p.m.~~

Loaded ~~Empty~~. Time repaired 1-23 ~~a.m.~~ 6 p.m.

Defects Side sills and Draft timbers broken.

C. George. Inspector at Temple

CAR No.

BAD ORDER CARD—SANTA FE.

BONUS SCHEDULES—EDUCATION OF TIMEKEEPERS AND INSPECTORS.

In the administration of bonus or piece work schedules, a prolific source of trouble lies with the timekeepers and inspectors. These men control the making or marring of the success of the schedule. Not enough attention has been paid to them. As a rule they have been given schedules to install and left to work out their own salvation. Bonus or piece work schedules are like all books of rules, capable of being interpreted as the individual opinion dictates. Left to himself the timekeeper, being in contact with the workman, will, when called upon to give a decision, not being certain (through ignorance), usually side with the workman. Even if when starting the bonus, all timekeepers are carefully drilled, there still exists the uncertainty that they may either quit and other men take their places, or they may forget their first instructions. To obviate this trouble and secure a uniform method of applying the schedule and timekeeping, weekly examinations are held. A list of test questions is sent to every timekeeper, which he answers and returns to the bonus supervisor for correction. The corrected paper is returned to him. From his examination the timekeeper is rated and a card form, as shown in one of the illustrations, is kept in the supervisor's office showing the standing of each man.

Men who fall below 85 per cent. are either removed, or placed with other timekeepers and given the opportunity to learn. At the main shops weekly classes are held, which timekeepers and foremen attend; any workmen desiring to fit themselves for promotion are given examination papers, similar to those for the timekeepers. These men make good emergency timekeepers and are given preference when a vacancy occurs. At these classes the questions of the examination are thoroughly gone over and all points made clear, also any questions are answered that may have arisen during the week regarding the application of a schedule.

The result is that there are now few irregularities in the correct interpretation of schedules and there is a remarkable uniformity in their application. The foremen know as much about the schedules as the timekeepers themselves and can answer the questions of the workmen without referring to the timekeeper. They know at once whether men are being justly treated and this gives a double check on the work. Inasmuch as men, as a rule, do wrong through ignorance, one can feel fairly certain

timekeeper draws off on a bonus card for each man, his part of the time allowed to repair the car and the time actually taken. The comparison of the total of these times at the end of the month determines a man's efficiency and his bonus. The car number being drawn off also, a record is available of the cars repaired by each man, furnishing a ready check of the work done by any man from start to finish.

The bad order card finally is filed according to the last two numbers of the car and remains as a permanent record of all repairs

STANDINGS OF BONUS CLASS. ________ DIV.

NAME	TITLE / RATE	LOCATION	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE
ABBOT, GEO.	B.T.K	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	75.00		100	95	97	38	92	76	88	98
BAIRD, G.O	B.T.K.	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	75.00		94	71	69	63	94	90	100	100
BORACK, W.	B.T.K	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	85.00		100	98	ABS.	99	ABS	87	92	100
DARNWELL, H.	B.T.K.	TEM.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	75.00		13	67	70	82	99	100	98	71
WATERS, H.M.	B.T.K.	GALV.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	60.00		36	75	90	85	99	84	80	91
LUNDBERG, C.	FOREMAN	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	90.00		100	82	94	98	71	84	100	98

RECORDS OF EXAMINATIONS OF BONUS TIMEKEEPERS.

made. This card eliminates shop inspector's records and also the foreman's office record of cars repaired, which is usually copied by a clerk from the repair yard inspector's record. The older records were not always complete. Repairs other than those which at first appear necessary often develop, and under the old method the workmen were simply told to make these. Now they are allowed time for repairs shown on repair cards and no one but the inspector or timekeeper is allowed to take from or add to the original; thus all repairs are necessarily recorded.

In addition, the cards being placed on the side of the car enables the foreman at any time to see how the men are progressing and to estimate when he may expect the work to be completed. He is not compelled to take the man's word for the amount of work done, or the time consumed. He can, at a glance, see just what the work is, and whether or not the men are working efficiently. The workmen have not the complaint, sometimes made, that they do work for which they are allowed neither time nor pay.

Hall 7 07 10M 6G9

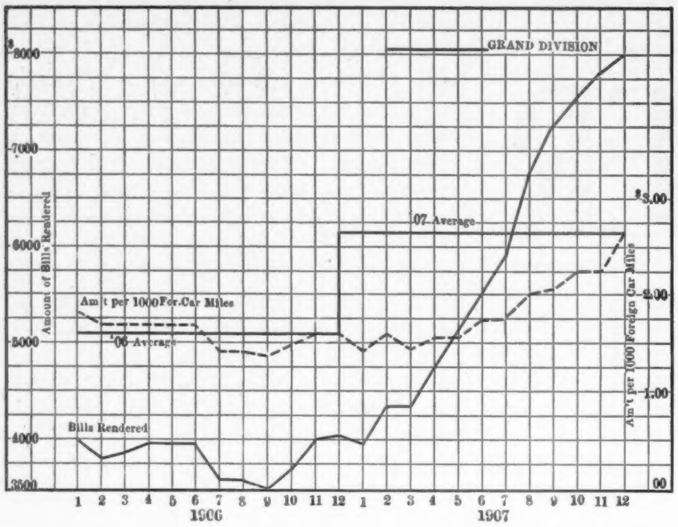
Form 2202 Standard.

BONUS TIME RECORD, CAR DEPT. MO. JAN YR. 1908

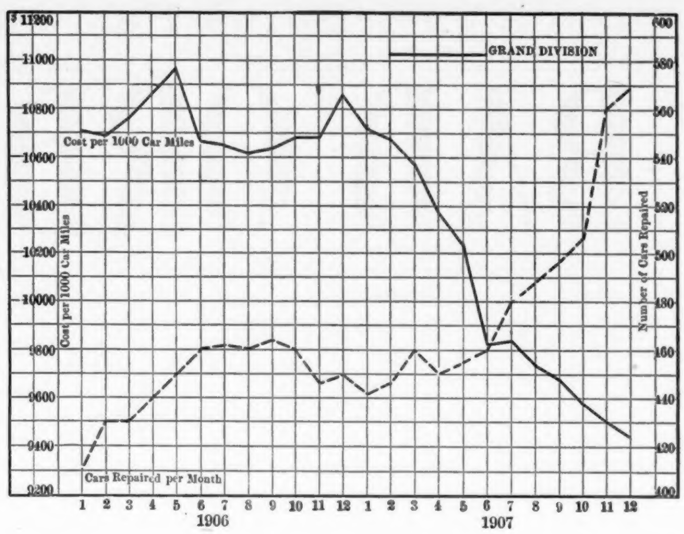
NAME Cox, J.C. No. 1301 ACT. TIME 234 STD. TIME 273.1 % EFFE. 116

Car No. ~~or Charge~~	Day	Act. Time Hr.	Act. Time Min.	Std. Time Hr.	Std. Time Min.	Car No. ~~or Charge~~	Day	Act. Time Hr.	Act. Time Min.	Std. Time Hr.	Std. Time Min.	Car No. or Charge	Day	Act. Time Hr.	Act. Time Min.	Std. Time Hr.	Std. Time Min.	Car No. or Charge	Day	Act. Time Hr.	Act. Time Min.	Std. Time Hr.	Std. Time Min.
92818	1/3	7		10	21	576	18-20 21	6		9	42												
11133	3/4	4	30	5	48	12820	20, 21	5	30	6	39												
2039	4/7	5		7	48	WK'S TOTAL		132	30	168	03												
WK'S TOTAL		16	30	23	57	18511	21-24	23	30	27	09												
53360	9		30		30	16227	29	5	30	6	51												
87842	3-4 5-6	14	30	14		17938	24-30	29		31													
92272	6,7	6	30	9	03	PLATFORM	18	1	30	1	30												
5006	6	7	30	8	15	694	31	3		3													
93635	9	1	30	2	30	250018	27-31	20	30	17	42												
94947	11-13	2		4	12	98163	31	1		1													
19005	11-13 14	18	30	19	45	40087	20-22	7	30	8	51												
6031	10-11 13	5		7	06	44832	2-4	10		8													
93705	11	2		2	45	TOTAL		234		273	06												
6114	11-15	6	30	9	05																		
616	9-10	11		9	30																		
94979	16	2		2	36																		
94788	16	2		2	24																		
WK'S TOTAL		96		115	42																		
94621	17	2		2																			
94981	17	2		2	30																		
9439	17	3		4	36																		
125030	17-18	7		11	54																		
88816	14-15 16-17	11		15																			
		121		151	42																		

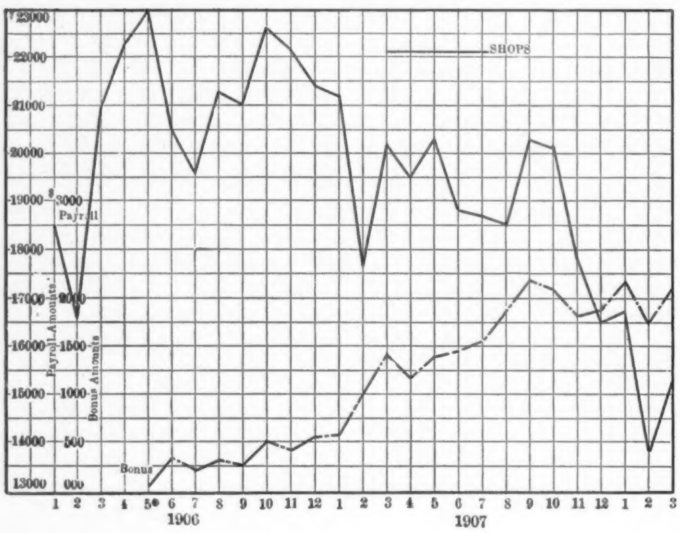
BONUS RECORD OF A CAR REPAIRMAN FOR ONE MONTH.



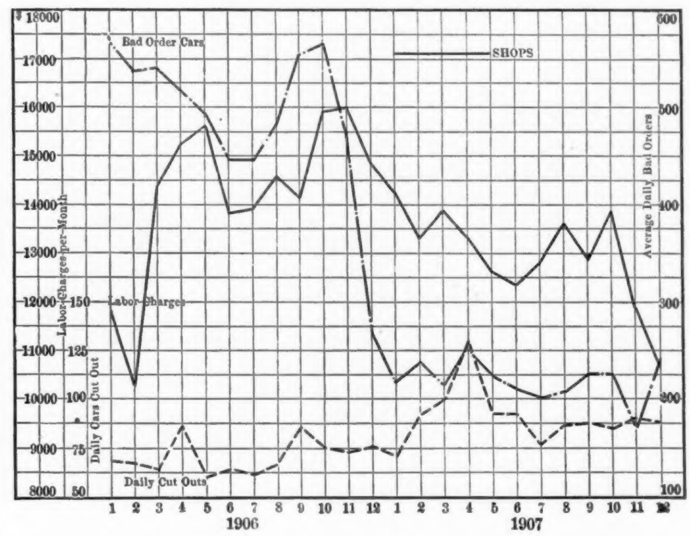
GRAPH SHOWING 12 MONTHS AVERAGES OF M. C. B. BILLS RENDERED AGAINST FOREIGN COMPANIES; 12 MONTHS AVERAGES OF AMOUNT PER 1,000 FOREIGN CAR MILES AND AVERAGES FOR 1906 AND 1907 OF AMOUNT BILLED PER 1,000 FOREIGN CAR MILES.



GRAPH SHOWING COST PER 1,000 FREIGHT CAR MILES AND NUMBER OF CARS REPAIRED PER MONTH.



GRAPH SHOWING PAYROLL (INCLUDING BONUS) AND AMOUNT PAID MONTHLY AS BONUS.



GRAPH SHOWING LABOR CHARGES PER MONTH FOR FREIGHT CAR REPAIRS; DAILY AVERAGE PER MONTH OF BAD ORDER CARS AWAITING REPAIRS AND DAILY AVERAGE PER MONTH OF BAD ORDER CARS CUT OUT FOR REPAIRS.

that if every timekeeper knows how to handle the schedule, it is being properly handled. As a safeguard against possible inaccurate handling of schedules, surprise checks are made by either visiting local points, or having the repair cards sent in and the men's methods of handling checked.

M. C. B. Rules—Classes for Studying.

Of equal importance to the correct interpretation of the schedules is the thorough understanding of the M. C. B. code of rules, the proper making of bills and the handling of interchange work. Few roads make much, if any, effort to educate their inspectors to the proper application of the M. C. B. code. They employ skilled men at good salaries at the head bill clerk's desk, but forget entirely the man who actually makes the bills. If it is so necessary that the head bill clerk be highly efficient, why is it not increasingly more important to educate the man who makes the bills? A small effort at the bottom must necessarily be felt with increased force at the top.

To bring about better results a weekly M. C. B. bill class was organized. Each Monday evening all shop foremen, bill clerks, bonus timekeepers and inspectors, and as many of the ambitious workmen as desired to attend, were instructed in the proper making of bills and interchange work. On a large blackboard a fac-simile of a standard repair card was drawn. Imperfect examples were written on the board and the members of the class were asked to correct them. Each problem was worked over until fully understood by everyone present. Verbal problems were given and the men were required to write them on the board. They were asked questions to test their knowledge of interchange work. To gauge the good accomplished, monthly written examinations were given in the class room and answers were expected to be written from memory. Each man's paper was corrected and returned to him with his grading and a correct set of answers.

All inspectors not able to attend the classes were educated and examined by letter. As the foremen, inspectors and bill clerks were required to attend these classes, those with an insufficient knowledge of the M. C. B. code were soon discovered. When a car inspector could not pass an average of 72 per cent. on three examinations he was returned to the shop. All this created a positive desire on the part of those interested to show their ability in applying the rules. Further, it naturally had a strong tendency to increase the number of correct bills rendered and to decrease the number of disputed bills.

Aid for Making Correct Repair Bills.

To still further aid those making the bills, a pamphlet was prepared showing accurately what should be shown on a bill to cover repairs made and why made. Two examples of this are as follows:

- Brake Beam
  - Oak
    - Number of beams applied.
    - Kind of material.
    - Size of material.
    - Number and size of bolts applied.
    - Solid or trussed beam.
    - Amount of paint used.
    - End of car.
    - Cause of renewal.
  - Metal
    - Number of beams applied.
    - New or second-hand.
    - State name of beam applied.
    - Renewed or repaired.
    - State whether beam is missing or broken.
    - Kind of beam removed.
    - Specify part broken.
    - End of car.
    - Cause of renewal.
- Coupler
  - Number of couplers applied.
  - New or second-hand.
  - Kind of material in coupler applied.
  - Name of coupler applied.
  - Size of shank.
  - Kind of attachment.
  - Kind of material in coupler removed.
  - Name of coupler removed.
  - Specify the parts of coupler broken.
  - Kind of knuckle removed and applied (open or solid).
  - Condition of other parts.
  - End of car.
  - Cause of renewal.

The main trouble in the past has been that some important item was frequently left off the stub, or something unnecessary was added. This pamphlet instructs a man how to make out a repair card stub properly; as it has been printed and added as an appendix to the M. C. B. rule book, it can be easily followed.

That the efforts expended in such methods of education have been fully rewarded, is shown in the manner in which the foremen are now handling their work, in the interest they are taking in the successful operation of bonus, and in the improvements they are installing to increase output and work the men to the best advantage and the highest per cent. of efficiency. The foremen take as much interest in the condition of the cars as the inspectors and make it their business to see that they are repaired in the least possible time and at a minimum cost.

For some time vacancies for foremen and inspectors have been filled from members of the educational classes, and the ability of the man is thus known before appointment. Every one of the inspectors on the road has been through a rigid written examination on M. C. B. rules, in which answers can only be gotten through actual knowledge; every new inspector must have a percentage of 72 in order to qualify. This has raised the standard of the car department force much above the average and has made the men now on the road fully in favor of all the new methods and improvements instituted, since they themselves have been a part of them. This course of instruction has improved the interchange inspectors and enables them to use their judgment to better advantage than before the classes were started; the lessening of complaints is quite noticeable. Almost any improvement in the shops that has the hearty and intelligent support of the foremen is bound to succeed, and the reverse is also true. Only partial success can be expected when the foremen are indifferent. The interest taken by the foremen in the class work has been quickly reflected by the attitude of the workmen; plans for improvement that had previously been tried and met with scant success now go through without a hitch.

NUMBER OF MEN TO WORK IN A GANG.

General practice in many shops is to bunch men on a car with the idea of rushing the work, or with the desire of getting a heavy car (badly placed among a number of lights) repaired at the same time the lights are ready. Ten, twelve, and even more men are often placed on a car. The co-operation of men and foremen soon eliminated this and determined the best number. Tests were made on a number of cars requiring similar repairs. A gang of six men developed an efficiency of 86 per cent.; four men, 92 per cent.; and two men, 104 per cent. As a result of this test two men are now considered the maximum number to be worked on the body of the car and two on the trucks; as both foremen and men are affected by the increased efficiency, no trouble is found in enforcing this rule.

DELIVERY OF REPAIR MATERIAL.

Another serious drawback for the workmen has been the method of securing the material. Usually each man was supposed to be his own supplyman and a large portion of his time was consumed looking for material. When he was missed by his foreman, the excuse was offered that he was hunting material. In order to overcome this, a supply gang has been organized whose duty it is to keep up a stock of all necessary small material at convenient sub-stores from which every repairman can draw what he needs. The main, or shop storehouse, is in charge of a storekeeper, who is always on duty at that point, and is required to see that the regular stock is kept up. When material is wanted by a supplyman and is not in stock, the order for such material is given the shop storekeeper and he draws from the general storehouse. Repairmen secure all their small supplies, such as bolts, nuts, nails, etc., from sub-stores, which prevents the ordering of unnecessary material as would be the case if it were delivered to them; all other material is delivered to the car by the supply gang whose leader secures the list of supplies needed and sees to the handling of all material to and from the shops during its manufacture.

Increased efficiency has resulted in increased output, decreased unit cost and decreased payrolls. With increase in efficiency and the resultant increase in bonus payments, the total payroll (bonus included) decreased, while the number of cars repaired increased. This efficiency is reflected in the decreased cost of repairs per car and car mile and in the first-class condition of the rolling stock. The accompanying diagrams show clearly the results of the introduction of the betterment methods.

PAY OF AMERICAN RAILROAD EMPLOYEES.

The report of the Interstate Commerce Commission for the year ended June 30, 1906 (full report just issued) gives the following table of the average daily pay of railroad employees for the years 1896-1906. The figures indicate dollars and cents.

Class.	United States.										
	1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.	1898.	1897.	1896.
General officers	11.81	11.74	11.61	11.27	11.17	10.97	10.45	10.03	9.73	9.54	9.19
Other officers	5.82	6.02	6.07	5.76	5.60	5.56	5.22	5.18	5.21	5.12	5.96
General office clerks	2.24	2.24	2.22	2.21	2.18	2.19	2.19	2.20	2.25	2.18	2.21
Station agents	1.94	1.93	1.93	1.87	1.80	1.77	1.75	1.74	1.73	1.73	1.73
Other station men	1.69	1.71	1.69	1.64	1.61	1.59	1.60	1.60	1.61	1.62	1.62
Enginemen	4.12	4.12	4.10	4.01	3.84	3.78	3.75	3.72	3.72	3.65	3.65
Firemen	2.42	2.38	2.35	2.28	2.20	2.16	2.14	2.10	2.09	2.05	2.06
Conductors	3.51	3.50	3.50	3.38	3.21	3.17	3.17	3.13	3.13	3.07	3.05
Other trainmen	2.35	2.31	2.27	2.17	2.04	2.00	1.96	1.94	1.95	1.90	1.90
Machinists	2.69	2.65	2.61	2.50	2.36	2.32	2.30	2.29	2.28	2.23	2.26
Carpenters	2.28	2.25	2.26	2.19	2.08	2.06	2.04	2.03	2.02	2.01	2.03
Other shopmen	1.92	1.92	1.91	1.86	1.78	1.75	1.73	1.72	1.70	1.71	1.69
Section foremen	1.80	1.79	1.78	1.78	1.72	1.71	1.68	1.68	1.69	1.70	1.70
Other trackmen	1.36	1.32	1.33	1.31	1.25	1.23	1.22	1.18	1.16	1.16	1.17
Switch tenders, crossing tenders, and watchmen.	1.80	1.79	1.77	1.76	1.77	1.74	1.80	1.77	1.74	1.72	1.74
Telegraph operators and dispatchers.	2.13	2.19	2.15	2.08	2.01	1.98	1.96	1.93	1.92	1.90	1.93
Employees—account floating equipment.	2.10	2.17	2.17	2.11	2.00	1.97	1.92	1.89	1.89	1.86	1.94
All other employees and laborers.	1.83	1.83	1.82	1.77	1.71	1.69	1.71	1.68	1.67	1.64	1.65

It will be seen that while the wages of officers, other than general officers, have decreased about 2.3% in the last ten years, the wages of enginemen have increased 13%; of firemen, 17½%; of machinists, 19%, and of the ordinary shop men, 14%.

TEST OF MALLET ARTICULATED COMPOUND LOCOMOTIVE

ERIE RAILROAD.

This test was made on one of the three locomotives delivered to the Erie Railroad by the American Locomotive Company in September, 1907, which have the distinction of being by far the largest and most powerful in the world. There were no special preparations made for the test, the locomotive being simply withdrawn from its regular service of pushing heavy trains on a very steep grade east of Susquehanna long enough to apply the apparatus and instruments for testing. During its six months' service it had received but the lightest kind of running repairs and at the time of the test it was in what might be called good condition, but not in such shape as to obtain the very best results.

The tests were made with the locomotive in its regular service, which consisted of taking its turn in pushing such trains up the grade as came along in the regular course of operation. No special trains or special loads were prepared for the purpose of testing and in each case there was a regular road locomotive at the head of the train, working to its capacity. This gave a load on the pusher engine which varied with the location of the whole train on the curves and grades and on the operation of the head engine. As a result there is no way of knowing the exact tonnage that was handled at any point of the test.

The power delivered by the locomotive was obtained by means of a dynamometer car placed between it and the train. This car, unfortunately, was not of sufficient capacity to indicate the full power of the locomotive when operated at its maximum rate, but was of sufficient capacity to give dynamometer records for a large part of the time on the test runs, the locomotive then being operated to deliver sufficient power to get the train over the hill at a speed which averaged six miles per hour.

The test as a whole, owing to the small capacity of the dynamometer car, to the small number of runs made, and to the fact that the operation of the locomotive could not be controlled by the testing crew, cannot be considered to be entirely satisfactory, nor can its absolute accuracy be vouched for. It does, however, clearly show a number of features in connection with this design of locomotive which are of greatest interest and importance. The reading of the instruments, taking the indicator cards, the weighing of the coal, etc., was done with the greatest accuracy and the lack of confidence in the results given is due to the impossibility of checking them with other runs under the same load, which allows any abnormal condition of operation, that might affect the figures to a large degree, to remain undiscovered. A number of the general results and the log of a couple of the runs are presented, which are to be understood to be simply illustrations of what the locomotive was doing at that particular time and under the conditions there prevailing.

These locomotives, as mentioned above, are the largest and most powerful ever built and were fully illustrated and described in the September, 1907, issue of this journal, page 338. They have the following general dimensions:

Service	Pushing
Fuel	Bit. Coal
Tractive effort, compound	94,800 lbs.
Weight in working order	409,000 lbs.
Weight on drivers	409,000 lbs.
Weight of engine and tender in working order	572,000 lbs.
Wheel base, rigid	14 ft. 3 in.
Wheel base, total	39 ft. 2 in.
Wheel base, engine and tender	70 ft. 5½ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.32
Total weight ÷ tractive effort	4.32
Tractive effort × diam, drivers ÷ heating surface	910.00
Total heating surface ÷ grate area	53.14
Firebox heating surface ÷ total heating surface, per cent	6.46
Weight on drivers ÷ total heating surface	76.90
Volume equivalent simple cylinders, cu. ft.	24.00
Total heating surface ÷ vol. cylinders	222.00
Grate area ÷ vol. cylinders	4.17
CYLINDERS AND BOILER.	
Kind	Mellin compound
Number	4
Diameter	25 and 39 in.
Stroke	28 in.
Kind, H. P. valves	Piston
Kind, L. P. valves	Richardson Bal. Slide
Greatest travel	5½ in.
Outside lap, H. P.	1⅛ in.
Outside lap, L. P.	1 in.
Inside clearance	¼ in.
Lead in full gear	3/16 in.
Driving wheels, diameter over tires	51 in.
Style of boiler	Straight, with Conical Connection
Working pressure	215 lbs.
Outside diameter of first ring	84 in.
Tubes, number and outside diameter	404—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4,971.5 sq. ft.
Heating surface, firebox	343.2 sq. ft.
Heating surface, total	5,313.7 sq. ft.
Grate area	100 sq. ft.

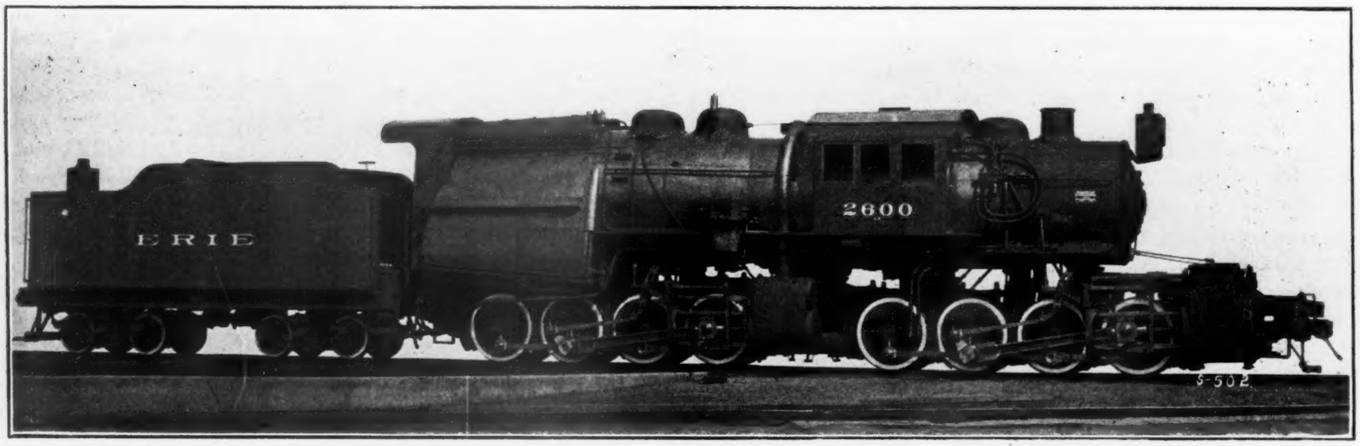


FIG. 1.—MALLET ARTICULATED COMPOUND LOCOMOTIVE OF THE TYPE TESTED ON THE ERIE RAILROAD.

Methods of Testing.

Weighing the Coal.—Owing to the fact that the locomotive operated but seven miles from its terminal, pushing up the grade and then coasting back, during which time it might use to a maximum of four tons, it was possible to use a very convenient and accurate method for weighing the coal. This scheme consisted in erecting a heavy board partition across the coal space in the tank, about 3 ft. back from the coal gates, and putting the supply of coal back of this partition. Just ahead of the partition a Fairbanks scale was secured and an iron barrel, holding about 250 lbs. of coal, was placed on the platform of the scale. A sheet iron chute was arranged above this and two men standing upon the pile shoveled the coal into the barrel, which was then weighed and the coal dumped on the floor of the tender just at the coal gate, the most convenient point for the fireman. In this way it was possible to get an absolutely accurate weight of the coal used during the test.

The greatest chance for inaccuracy at this point was in the necessity of the fireman having his fire in practically the same

condition at the beginning and at the end of the run. Owing to the short time of each run and the necessity for having an exceptionally good and heavy fire at the start, this feature could exert a considerable influence on the results. In fact, the coal records for the second run have been left out of the table published herewith, on this account, as it was clearly evident that the amount of coal actually used was not in keeping with the power developed.

Measuring the Water.—The amount of water used was obtained by very carefully calibrating the tank when standing upon a track scale and getting the weight of water for each inch of depth. This depth was carefully measured at the beginning of the run, a definite point in the road, where the angle of the tender was known and correction made, and also at the end of the run where a level track was obtainable. The height of the water in the boiler was carefully brought to the same level and the waste at the injector was measured and deducted. As far as the evaporation of the water from the boiler is concerned, the results are entirely reliable. There was practically no popping off at any point, the air pump was not in operation during the run, the blower was not in use at any time during the runs given herewith, the boiler was tight at every point and all of the steam evaporated went through the cylinders except such slight amount as was used by the whistle.

Calorimeters.—The quality of the steam was taken by throttling calorimeters, the thermometer and gauges being carefully calibrated, both before and after the tests. The high pressure quality was taken from the branch pipe through an approved form of sampling pipe, at a point about 3 ft. below its connection through the boiler shell to the short dry pipe. The sample of the steam in the receiver was taken close to the joining of the U-shaped pipe just back of the low pressure cylinders, where the steam from the receiver separates to go to each of the low pressure valve chests. The connections to the calorimeters were most thoroughly and carefully lagged with about 1½ in. covering of asbestos sheets wrapped on, all being covered with a double wrapping of canvas secured with a wrapping of heavy cord. The calorimeters were turned on and left in that condition throughout the run, readings being taken at the time of taking indicator cards and other observations.

Indicators.—The connection to the indicators was made from the openings in the side of the cylinders, provided for that purpose, through ¾ in. pipes, having bends of the largest possible radius, to the three-way cock on top of which the indicator was mounted. These pipes were also very carefully lagged with asbestos and canvas. The length of pipe from the indicator to the cylinder on the high pressure cylinders was about 3 ft. and on the low pressure cylinders about 4 ft. 6 in.

The reducing motion consisted of a reducing wheel properly adjusted for the length of stroke, so as to give approximately a 3½ in. card. These were so arranged and connected to the indicator as to allow the disconnecting of the cord between the reducing wheel and the indicator drum to allow the application of the indicator cards. The cord from the reducing wheel was led to a light but stiff bracket projecting out and upward from the cross head.

This arrangement of reducing motion was very satisfactory on the whole, but gave very serious trouble when the engine would slip for several revolutions, at which time the cords would be snapped. This made it necessary to delay the starting of the test until the engine was well under way when the possibility of slipping, greatest at starting, had been largely eliminated.

Vacuum Gauge.—The vacuum in the front end was obtained by the reading of a water manometer, which was connected by a short section of rubber tubing to a ¾ in. pipe projecting two-thirds the distance across the front end at a point about 1 ft. ahead of the diaphragm apron and about 6 in. above its bottom edge. This pipe was open at the end and contained a spiral series of ⅛ in. holes spaced about 3 in. apart for two-thirds of its length.

Flue Gas Analysis.—The sample of flue gas was taken through a ¾ in. pipe, located about 6 in. ahead of the vacuum gauge pipe, which was plugged at the end and had a series of ¼ in. holes, 3 in. apart, drilled in a straight line for its entire length. This pipe extended across the center two-thirds of the width of the front end at this point and was continued by an elbow through the front end ring to the sampling connection. The samples were very carefully taken, there being at least one full bottle wasted before the sample was taken. The analysis was made in an Orsat apparatus located in the dynamometer car. Samples were taken as rapidly as they could be analyzed. The analysis was made for CO_2, CO and O, the N being obtained by difference. The average figure for the series of each run is given in the table. The apparatus was not in working order for the first run.

Revolution Counters.—A revolution counter was attached to each set of engines, being located at a convenient point on the running board and having its cord connected to the valve gear link. These counters were read at intervals of one minute throughout the run.

Other Apparatus.—The pressures in the branch pipe and receiver pipes were taken from the gauges on the calorimeters, a valve being arranged so as to shut off the calorimeter temporarily from the gauge and give an accurate reading of the pressure. These gauges, as well as all other steam gauges, thermometers and indicator springs were carefully calibrated after the test. The coal sample was taken by shoveling 50 lbs. of coal, consisting of both lumps and fine, into a bucket; this was then dumped on to a platform, carefully crushed into fine bits, thoroughly mixed and a 1 lb. sample taken and sealed in a glass jar. The analyses were made at Cornell University, the figures given being an average.

The temperature of the feed water was taken at the beginning and end of each run and the temperature of the exhaust steam was taken at intervals of three minutes, a thermometer cup being inserted in the pipe connecting the exhaust passage with the nozzle.

The diameter of the wheels was carefully calipered at a number of points in the circumference of each and were found to vary but slightly on each set of engines. The figure used is an average of all of the observations on the wheels of each engine.

The boiler steam pressure, length of time of injector in action, and position of throttle and reverse lever were noted by the observer in the cab, who also gave the signal for the taking of cards and other observations.

Owing to the short time available for fitting up the locomotive it was necessary to give the signal for taking cards by means of a short blast of the locomotive whistle.

Dynamometer Car.—The dynamometer car used was owned by the Erie Railroad and was of the spring type. It had a maximum capacity of 70,000 lbs. and was of comparatively light construction. The underframe consisted of wooden longitudinal sills, to which the stops for the springs were fastened. The recording pen was connected directly to the spring by levers extending up through the floor. The paper was driven through a connection to the axle of one of the truck wheels which was arranged to drive the paper at a speed corresponding to 1 ft. per mile. As a check on this the time of passing mile posts was carefully noted on the record and the actual speed of operation was taken from these records by means of the 15 second notches obtained by electrical connection to a chronometer. The time of taking indicator cards and other observations was noted by an electrical pen movement on the paper.

It is felt that, owing to the entirely too light construction of the car for service ahead of a locomotive of this capacity, which at many times in starting, before the test was begun, compelled the disconnecting of the indicating apparatus from the spring to prevent it being destroyed and the spring at these times coming up solid and the remainder of the stress being taken by the connection of the springs to the wooden sills, the dynamometer records may be open to some question in that they may be slightly too high. The constant error would be due to any lost motion that there might be between the spring stops and the sills. Such an error if it exists has not been corrected for and in any case would probably not exceed 2,000 or 3,000 lbs.

The dynamometer car was in charge of Mr. R. B. Watson, engineer of tests of the Erie Railroad.

Run Number	Time in Minutes.	Front Engine. R. P. M. Max.	Front Engine. R. P. M. Min.	Front Engine. R. P. M. Ave.	Front Engine. M. P. H. Average.	Front Engine. Piston Speed ft. per min. Max.	Front Engine. Piston Speed ft. per min. Min.	Front Engine. Piston Speed ft. per min. Ave.	Back Engine. R. P. M. Max.	Back Engine. R. P. M. Min.	Back Engine. R. P. M. Ave.	Back Engine. M. P. H. Average.	Back Engine. Piston Speed, feet per Minute. Max.	Back Engine. Piston Speed, feet per Minute. Min.	Back Engine. Piston Speed, feet per Minute. Ave.	Pressure, pounds per sq. inch. In Boiler. Max.	Pressure, pounds per sq. inch. In Boiler. Min.	Pressure, pounds per sq. inch. In Boiler. Ave.	Pressure, pounds per sq. inch. In Branch Pipe.	Pressure, pounds per sq. inch. In Receiver.	Draft in Front End.	Injector in Action. Minutes.	Pounds Water. Delivered.	Pounds Water. Loss.	Pounds Water. Evaporated.	Dynamometer. Pounds, Maximum.	Dynamometer. Pounds, Minimum.	Dynamometer. Pounds, Average.
1	60	52	30	40	6.	244	141	187	47	30	40	6.	220	141	187	210	198	200	185	......	4.7	53	43,410	505	42,905	69,500	59,000	64,000
2	63	56	17	43	6.	234	79	187	51	14	40	6.	240	66	187	210	155	200	171	50	5.0	58	40,270	552	39,718	......	59,000	66,000
3	113	47	14	33	5.	220	66	154	50	14	33	5.	234	66	154	210	165	195	176	56	4.5	99	48,920	942	47,978	70,000	58,000	64,000

Run Number.	Boiler. Horse Power.	Boiler. Efficiency.	I. H. P. Right High Pressure.	I. H. P. Left High Pressure.	I. H. P. Right Low Pressure.	I. H. P. Left Low Pressure.	Division of Power. High Pressure.	Division of Power. Low Pressure.	Division of Power. Right Side.	Division of Power. Left Side.	Consumed Per I. H. P. Hour. Dry Coal.	Consumed Per I. H. P. Hour. Dry Steam.	Consumed Per I. H. P. Hour. B. T. U.	Locomotive. Total I. H. P.	Locomotive. Total D. H. P.	Locomotive. Per D. H. P. Dry Coal.	Locomotive. Per D. H. P. Dry Steam.	Locomotive. Per D. H. P. B. T. U.	Locomotive. I. H. P. Per sq. ft. H. S.	Locomotive. I. H. P. Per sq. ft. G. A.	Locomotive. D. H. P. Per sq. ft. H. S.	Locomotive. D. H. P. Per sq. ft. G. A.	Locomotive. Machine Friction. H. P.	Locomotive. Machine Friction. Darwbar Pull.	Locomotive. Machine Efficiency.	Locomotive. Efficiency.
1	1,520	80.5	317	309	248	267	626	515	565	576	4.3	37.2	54,000	1,141	1,021	4.8	41.6	60,000	.215	11.41	.192	10.21	120	7,500	89	4.24
2	1,330	....	257	251	251	253	508	504	508	504	....	36.9	....	1,012	889	......	42.4	....	.191	10.12	.166	8.89	123	7,700	88	......
3	900	61.	218	216	224	228	434	452	442	444	4.2	29.0	52,500	886	710	5.6	35.4	65,700	.166	8.86	.133	7.10	176	13,200	80	3.88

TABLE OF GENERAL RESULTS OF THREE RUNS. TEST OF MALLET ARTICULATED LOCOMOTIVE—ERIE RAILROAD.

Pyrometer.—A pyrometer, operating a hand on a dial by means of the expansion of an enclosed gas, was inserted in the front end at a location about the center of the flues and half-way between the flue sheet and the diaphragm. Owing, however, to the impossibility of calibrating this instrument for the temperatures at which it was used, and its gross inaccuracy at such temperatures as were available for calibration, made it seem advisable to eliminate the records obtained from it.

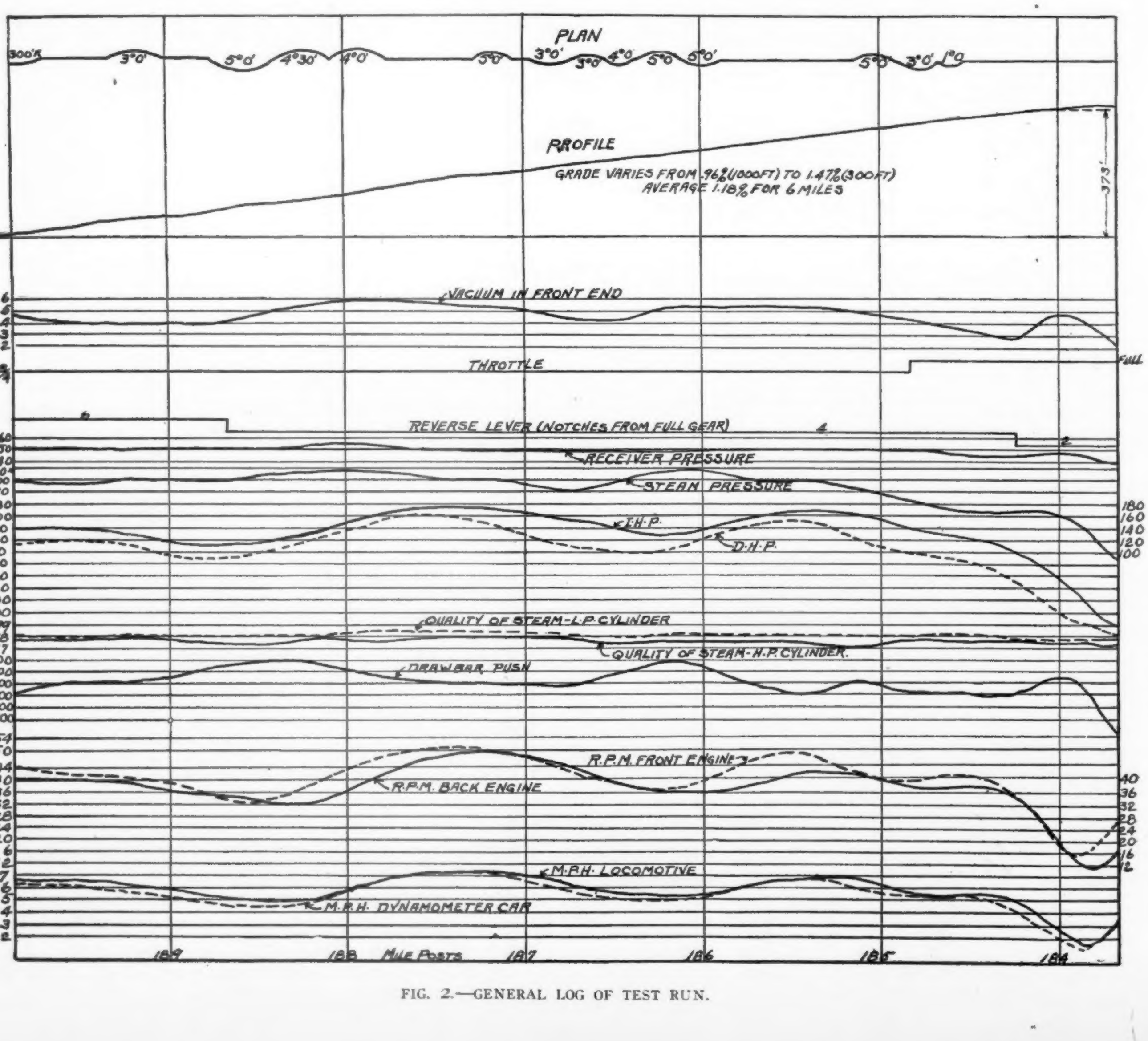


FIG. 2.—GENERAL LOG OF TEST RUN.

	Coal.													Flue Gas.				Quality of Steam.		Evaporation in Pounds.				Equivalent Evaporation from and at 212°.				
	Fired.			Total, Pounds.			Analysis of Coal.			Value in B. T. U.		Dry Coal Fired.								Steam per Hour.						Per Pound Coal.		
Run Number.	Kind.	Total, Pounds.	Moisture per cent.	Dry Coal.	Combustible.	Ash, by Analysis.	Fixed C.	Volatile Matter.	Ash.	Moist Coal.	Combustible.	Per Hour.	Per square ft. G. A.	Per Cent. O.	Per Cent. CO.	Per Cent. CO_2.	Per Cent. N.	Branch Pipe.	Receiver.	Moist.	Dry.	Dry per sq. ft. H. S.	Dry Steam per Pound Dry Coal.	Per Hour, Pounds.	Per square ft. H. S. Per Hour.	As Fired.	Dry.	Combustible.
1	Bit.	5,065	3.1	4,910	4,125	785	52.8	28.4	15.7	12,100	14,910	4,910	49.1	......	......	......	......	99.08	....	42,905	42,500	7.96	8.66	52,300	9.85	10.46	10.70	12.7
2	"	....	3.1	......	......	......	52.8	28.4	15.7	12,100	14,910	....	......	4.08	.36	12.68	82.67	97.65	98.05	37,900	37,065	6.95	....	45,800	8.62	......	......	......
	"	7,218	3.1	7,000	5,900	1,100	52.8	28.4	15.7	12,100	14,910	3,980	39.8	8.86	1.12	9.68	80.34	98.39	98.14	25,460	25,060	4.70	6.32	31,000	5.92	7.80	8.08	9.6

RESULT OF TESTS.

The log of two of the best runs, shown in Figs. 2 and 3, are self-explanatory. It will be noticed that there is a variation in the r. p. m. between the front and the rear engine, all of which is not accounted for by the difference in the diameter of the drivers. This, of course, is due to one of the engines slipping when the other did not. This, as will be seen from the curves, usually occurred with the front engine and was probably due to variation in the track, reducing the weight on this set of wheels for short periods. The actual slipping of the engine during the two runs illustrated was not sufficient to be noticeable and seldom exceeded a half of a revolution. There, of course, might have been, and probably was, a slight amount of slipping at various times which was not sufficient to attract attention.

The mile per hour curves of the locomotive and dynamometer car vary from the same causes. The speed of the locomotive was taken from the revolutions multiplied by the circumference of the drivers, the lower r. p. m. readings being used in each case, while the speed of the dynamometer car is taken from the record, as above explained. The indicated h.p. and dynamometer h.p. curves vary in exactly the same manner as do the speed curves and for the same reason. The plan and profile of the road, given at the top of each log, should be considered in inspecting these curves.

The table of general results presents some very interesting figures, which, however, as explained, are in some instances open to question. The first run will be seen to have been the best as far as economy is concerned and clearly illustrates the capacity of one of these machines when being fired by one fireman, who was not by any means seriously overworked. In connection with the amount of steam used per indicated h.p., which looks to be very large for a compound locomotive, it might be mentioned that at the time of these runs there was a considerable leakage of steam at the cylinders and that these wastes have not been deducted. This, of course, only affects the engine performance and does not enter into the boiler results. The quality of steam is noticeable, particularly that in the receiver, where over 98 per cent. steam was obtained practically all the time. This was a feature of the Mallet compound locomotive concerning which there had been some doubt, and the results show that in spite of the long and exposed receiver pipe the low pressure cylinders are getting nearly as dry steam as the high pressure and in the second run were even getting better on the average. This is probably due to the large volume

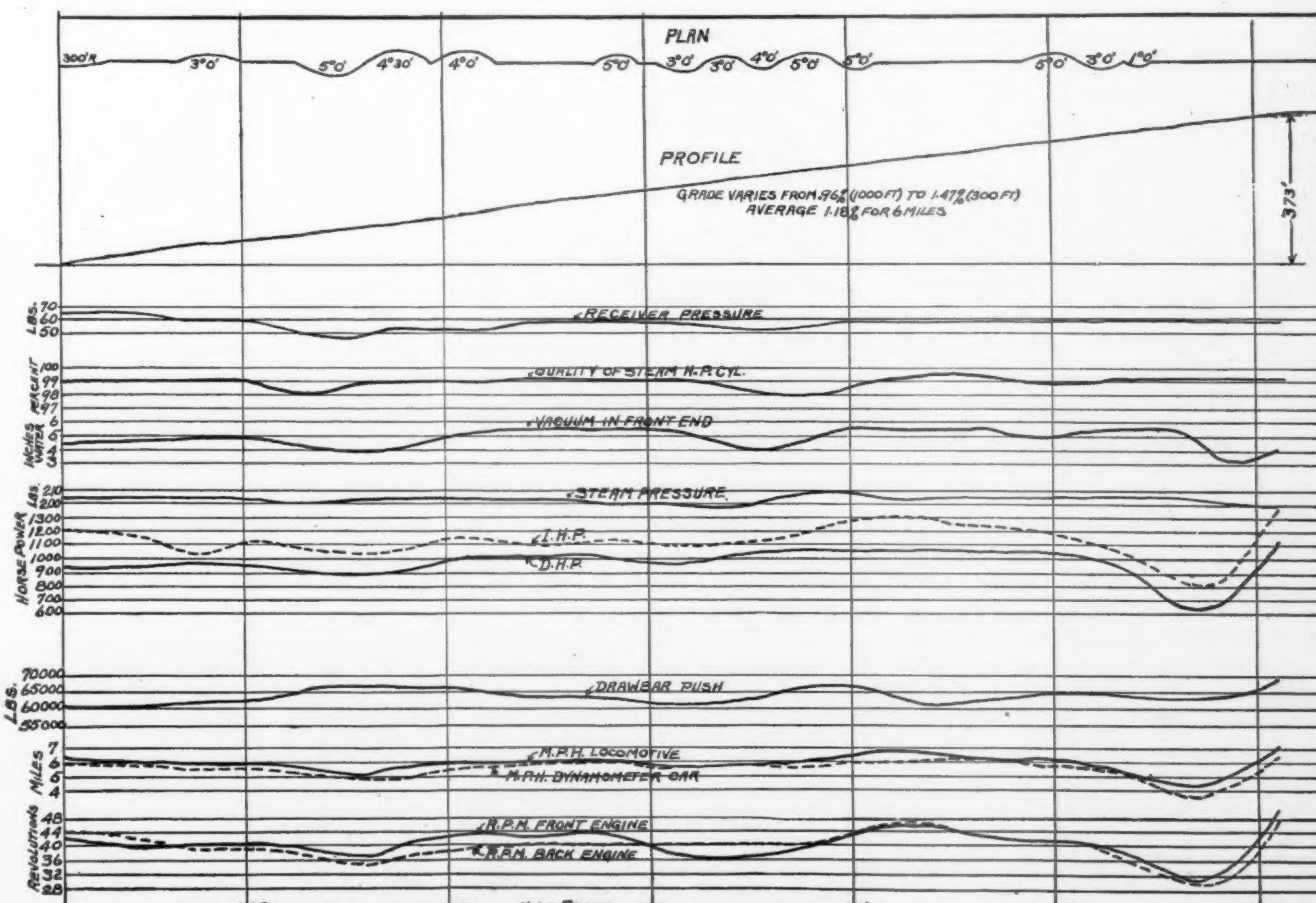
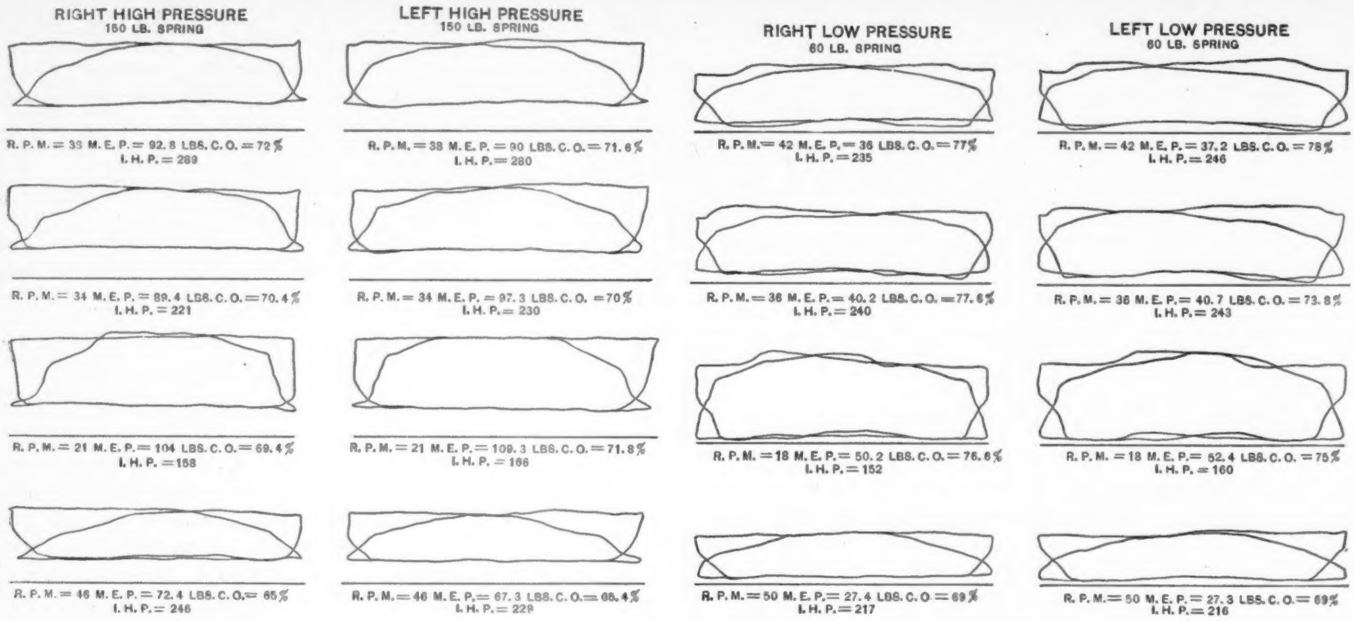


FIG. 3.—GENERAL LOG OF TEST RUN.



Top row illustrates the effect of a high pressure exhaust at about 1/8 stroke of low pressure cylinder. Second row illustrates the effect of a high pressure exhaust at beginning of low pressure stroke. Third row illustrates the effect of admission of high pressure steam to low pressure cylinder. Fourth row illustrates working at higher speed with very low boiler pressure and earlier cut off.

FIG. 4.—TYPICAL INDICATOR CARDS.

of the receiver pipe, which allows some wire drawing and consequently superheating of the steam in entering it from the high pressure valve chamber.

The poor results shown on the third run, as compared with the first and second, are explained by the fact that fireman was not of a grade equal to the men who fired the first two runs and did not maintain his fire in as good condition, or keep the steam pressure anywhere near as constant as did the other men.

In Fig. 4 are shown a number of typical indicator cards, the characteristics of which are noted in the caption under the cut. These cards indicate very clearly the effect of the exhaust of the high pressure cylinders on the pressure in the low pressure cylinders. This exhaust, of course, may come at any point in the stroke and actually does vary constantly. The ideal condition in this respect would be an exhaust coming just at the opening of the admission, about as shown in the second row of cards, or just following the point of cut-off, which is shown in one of the cards of the fourth row. In both cases the low pressure cylinders get the full benefit of this high pressure in the receiver at the beginning of the stroke. The cards, as a whole, present a number of points of interest, which are clearly evident in the illustration. It will be seen how the exhaust from one low pressure cylinder creates a considerable increase in the back pressure of the other cylinder, and also how the opening of the admission or the cut-off of the low pressure cylinders seems to have no appreciable effect upon the exhaust line of the high pressure.

In Figs. 5 and 6 are given some sample dynamometer car records, which will be seen to have some extremely unusual characteristics. A draw bar pull, particularly with a spring dynamometer car, which presents very nearly a straight line for a time of three minutes covering a distance of 2,000 ft., such as is shown in Fig. 5, would be practically impossible with any type of locomotive except a Mallet compound. Such a condition is, of course, due to the two sets of engines assuming a relation so that the cranks are an eighth of a revolution apart, thus together maintaining a constant and steady push, or pull. It will be noticed that just at the end of this section of straight line there is considerable variation in the draw bar push, which is undoubtedly due to one set of drivers slipping slightly and getting in step with the other. In examining these dynamometer car

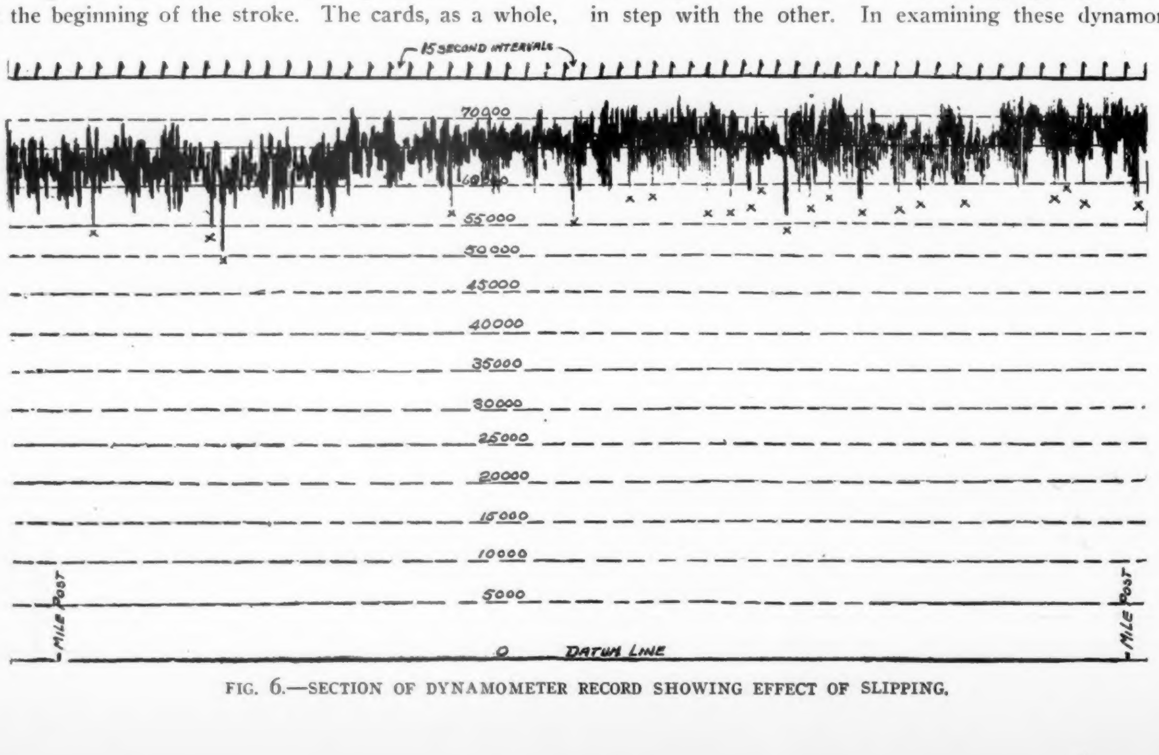


FIG. 6.—SECTION OF DYNAMOMETER RECORD SHOWING EFFECT OF SLIPPING.

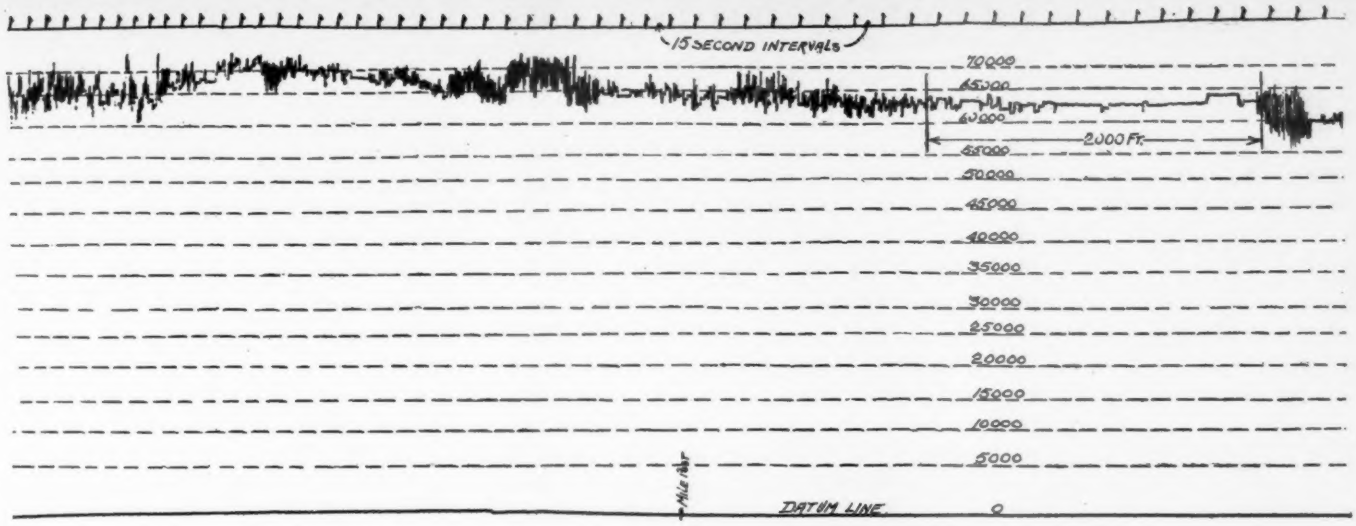


FIG. 5.—SAMPLE DYNAMOMETER RECORD SHOWING THE CONSTANT, STEADY TRACTIVE EFFORT.

records it should be remembered that there was a locomotive on the head end of the train and that any slipping or uneven operation of it would be conducted back through the train to the dynamometer car and set up a series of surges which would show on the record, although they might not be due to the pusher engine.

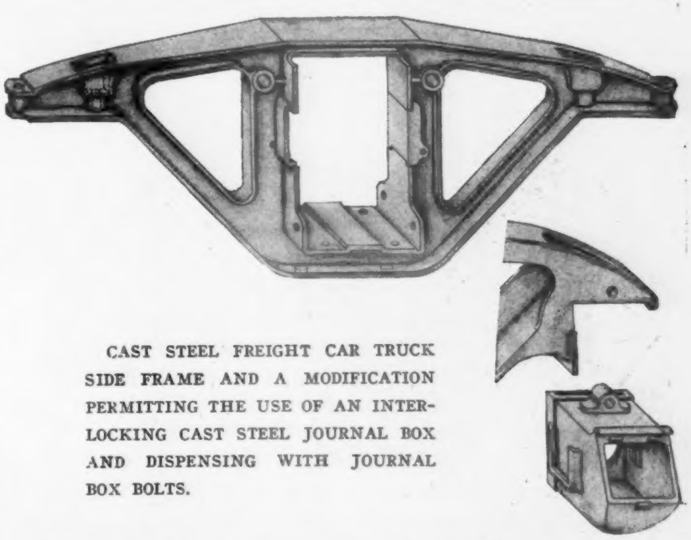
The record shown in Fig. 6 was a part of the run where there was a very poor rail, which, in connection with a shortage of sand, made the locomotive slip a great deal. It might be mentioned that this record is taken from a run which is not shown in the table of data. The points marked X in the illustration are the points of slippage and it can be seen that the draw bar push was reduced but very little by the slipping of the engine. This effect is obtained because of the fact that one set of drivers slipped at a time and that this slippage would seldom cover a whole revolution. For instance, when the low pressure engine would slip it would soon exhaust its supply of steam and necessarily stop. This would reduce the back pressure on the high pressure engine and it would exert a greater pull to counteract the loss on the low pressure. The reverse is also true because when the high pressure engine slips it rapidly builds up the back pressure in the receiver, thus decreasing its own power and increasing that on the low pressure. The dynamometer car record shows the net result very clearly. Both of these records show how closely to the capacity of the dynamometer the records were taken.

The arrangements for these tests were made and the apparatus was provided by Messrs. C. R. Cullen and S. D. Gridley, seniors at Cornell University, who are using the results as a basis for a thesis to be presented for graduation. The observers on the test were members of the junior and senior classes at Cornell and special apprentices on the Erie Railroad.

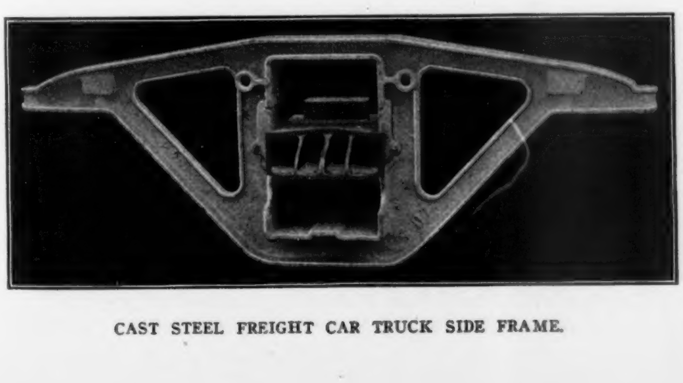
DEVELOPMENT OF CAR TRUCK SIDE FRAME CONSTRUCTION.

An interesting modification has been embodied in the design of a freight car truck frame, consisting of a separable cast steel journal box interlocking with a cast steel frame, thus dispensing with all column and journal box bolts in a strong and practical manner; a single bolt is applied as a key at each box to maintain the boxes in place in case of derailment. If desired, journal box bolt holes may be provided permitting the application of a standard M. C. B. box in combination with a tie bar, thus facilitating repairs in the event of an accident to the box on a foreign road. These frames are also made in a design to take the standard M. C. B. boxes only.

An important feature of both truck designs is the simple method by which the truck bolster is applied. An enlarged opening is provided near the center section of the column guides, of sufficient width to admit the flanged guides of the bolster. The bolster after being placed in position is either raised or lowered and the column guide opening closed with an interlocking filler securely locked against removal when the bolster is in its normal position.



CAST STEEL FREIGHT CAR TRUCK SIDE FRAME AND A MODIFICATION PERMITTING THE USE OF AN INTERLOCKING CAST STEEL JOURNAL BOX AND DISPENSING WITH JOURNAL BOX BOLTS.



CAST STEEL FREIGHT CAR TRUCK SIDE FRAME.

These filler-blocks are in no sense keys. When in place they become integral parts of the column and have no tendency to wear loose in service. Besides providing a renewable chafing plate this filler construction permits the application or removal of the truck bolster without the necessity of dismantling the truck. The truck is designed either with the spring seat cast integral or made to receive a separate cast steel or malleable spring seat. It is adapted to any form of spring plank or truck tie bar, or may be furnished with an interlocking cast steel spring plank.

The side frame is made of basic steel melted with natural gas. Basic steel made in this manner is uniformly low in sulphur and phosphorus; this is an important consideration in steel for truck side frames, which are subject to direct vibratory shocks. This truck side frame is manufactured by the Pittsburgh Equipment Company, House Building, Pittsburgh.

THE SOLUTION OF THE CRANK AXLE PROBLEM

By Howard H. Lanning.*

American locomotives are of the simplest design, with large factors of safety in the proportions of their parts. As a consequence they can be built cheaply and quickly, and can be repaired by the crudest means. In Europe it has been customary to give much more thought and attention to these matters, and the claim is made that it takes three years to build a locomotive over there; one year to thoroughly work out the design in all its details; a second year to build one or two of the type and thoroughly test them out for defects and possible improvements, and the third year to actually construct and put into serviceable condition the twenty, or may be one hundred locomotives of the class that the building programme calls for. The result of this painstaking method is the production of a beautiful and fine machine, capable of the very best work within its limits of size, and economical both to operate and to maintain.

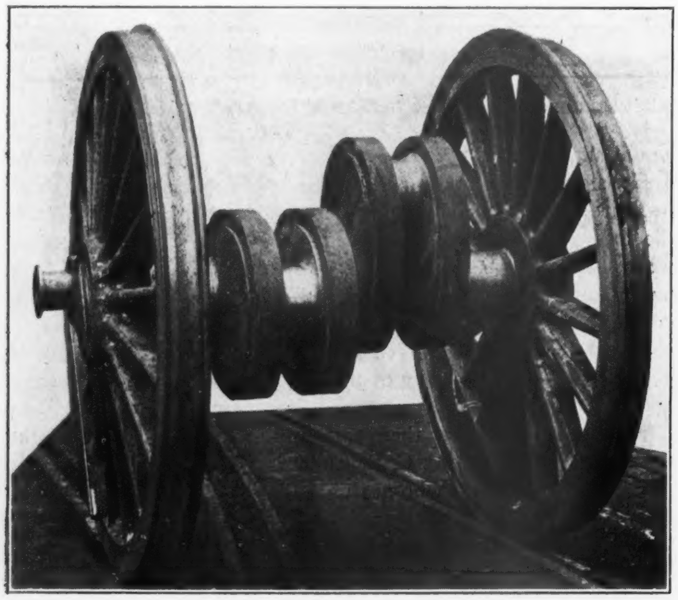


FIG. I.—EARLY TYPE OF AMERICAN SOLID FORGED CRANK AXLE WITH BANDED REINFORCEMENT.

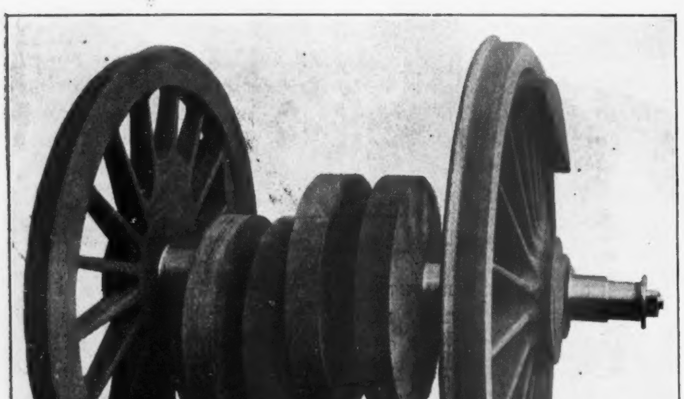


FIG. I A.—BUILT UP CRANK AXLE WITH FOUR CIRCULAR CHEEKS AND FIVE PINS.

The refinement and standardization of American locomotive design is only beginning. One of the refinements is the balanced compound locomotive. Locomotives with cylinders between the frames, with crank axles, have been in successful and almost universal use in England and France for two generations, and are also used extensively in other European countries. As it is not customary to overload engines in England and on the Continent, nor keep them on the road when they require shop attention, and as great armies of men and inspectors are continuously employed keeping each engine in the pink of condition, the difficulties of rough American usage do not occur; when Americans attempt to use fine machines of these types under their rough conditions, without the care and attention given abroad, many bad features develop, among which may be mentioned the pounding, heating and rapid wearing out of round of the inside crank pins.

On European railways these pins are not allowed to run hot, nor to get into a condition where they do run hot, and what slight wear does result is taken up by either careful hand work, or by machines of which the accompanying illustrations (Figs. 4 and 5) are a type. These machines require the wheels and axle to be removed from the engine.

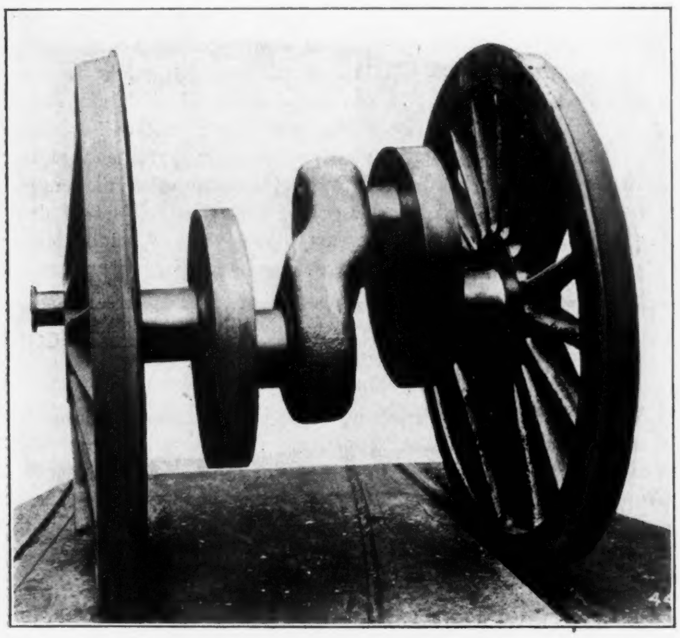


FIG. 2.—RECENT DESIGN OF BUILT UP SEMI-Z CRANK AXLE.

With the introduction of the balanced compound, or inside crank locomotive, in this country, the early troubles incident to undue wear of these pins were met either by hand work, or, as there were no examples of European locomotive inside crank turning machines available in this country, by the construction of special types of crank pin turning machines, according to American standards of machine construction.

The limited space between the frames of an American locomotive, into which the high pressure cranks must be crowded, makes it impossible to use a crank of proper proportions to resist wear and prevent heating and pounding.

The rapidity with which the high pressure crank pins of a balanced compound locomotive are worn out of round is often surprising. This is especially true with large Pacific and Prairie type engines, which are usually equipped with long and very heavy bifurcated high pressure connecting rods, spanning the front driving axle, and connecting the high pressure crossheads with the middle or main driving axle. The extreme weight of this style of connecting rod causes the crank pins to be worn

* Santa Fe, Topeka, Kan.

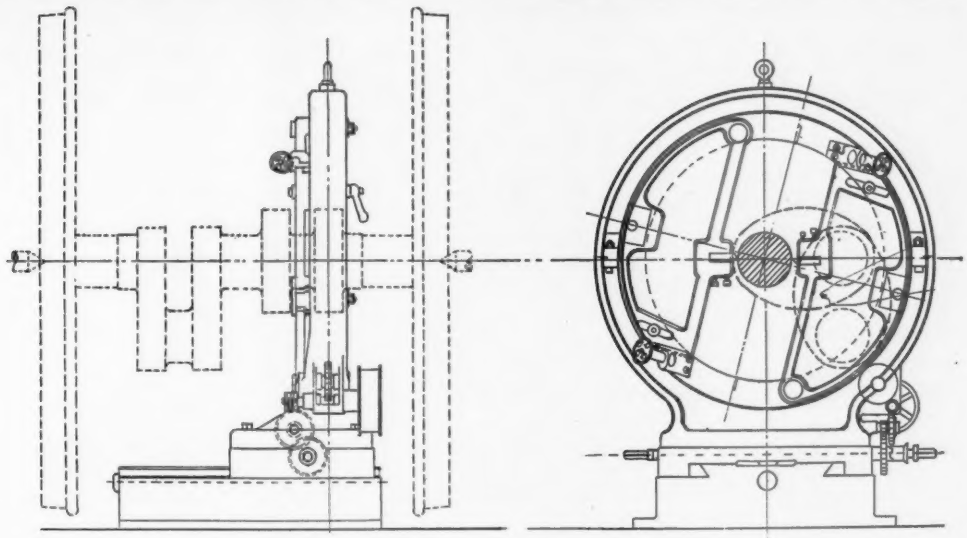


FIG. 4.—AN EUROPEAN CRANK AXLE RE-TURNING MACHINE.

away rapidly, as may be appreciated when it is known that 16 per cent. of all the engine failures occurring during a period of ten months service, to a class of fifty-one Pacific type balanced compound engines, were caused by some sort of trouble with the high pressure crank pins, or their connecting rods. These engines are used in heavy passenger service. Two new engines of this class were assigned to passenger service on a division having long and heavy grades; before they had been in service three months the inside crank pins were in such a condition that the back and high pressure rod brasses had to be renewed after every alternate round trip. Occasionally an extra strong set of brasses would survive two round trips and still remain intact, but they would be sure to come in after the third, either broken or burnt.

Since the first balanced compound engines were built, the locomotive builders of this country have made several improvements, which have lessened the inconvenience and expense of maintenance. One of these improvements is in the construction of the crank axle (Fig. 1). Most of the balanced compound locomotives, which have been built recently, are equipped with crank axles built up of from seven to nine separate pieces, pressed together. This construction permits of the removal and replace-

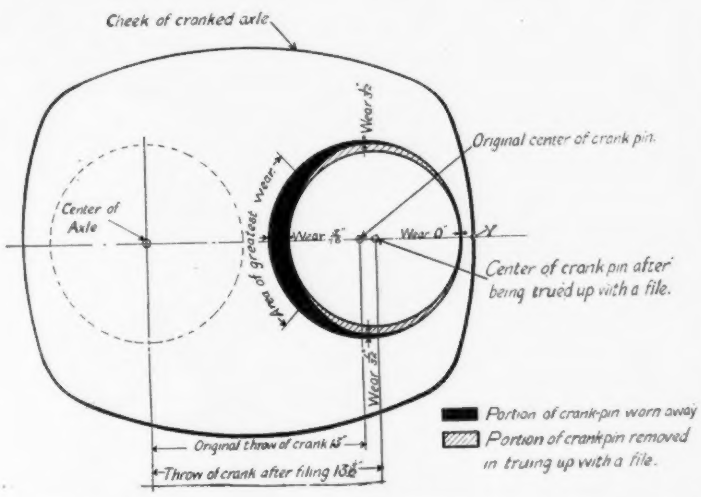


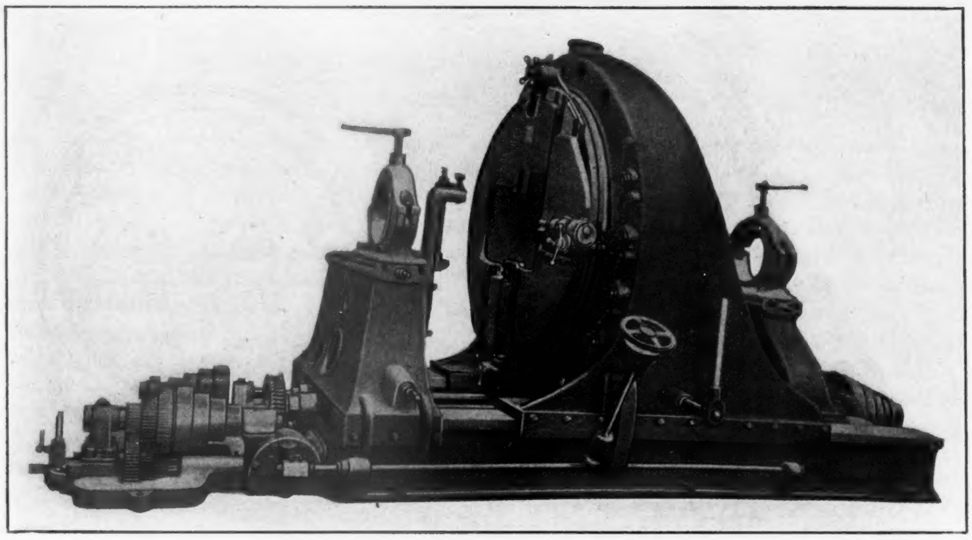
FIG. 3.—ILLUSTRATING THE WAY IN WHICH THE CRANK AXLE PINS WEAR OUT OF ROUND.

ment by a new part, of any member of the axle which may become broken or worn out. With this axle, a broken or worn out crank pin does not mean that the whole axle must be scrapped, as is necessary whenever anything goes wrong with the old solid forged axles. The axle shown in Fig. 2, known as the semi Z crank axle, is of this type, and is an improvement on the earlier form (Fig. 1a) which had two largs discs and a pin in place of the center forging.

A still later improvement, made by the Baldwin Locomotive Works in the design of some large Prairie type balanced compound engines, recently delivered to the Santa Fé System, consists of the elimination of the bifurcated rods. The high pressure cylinders of these engines are inclined several degrees to the horizontal and placed higher up in the cylinder casting than was formerly the practice. Such an arrangement obviates the necessity for the bifurcated rod, and makes it possible to use a straight high pressure connecting rod of minimum weight. That such improvements contribute largely toward preserving the contour of the crank pins of the engines to which they are applied, cannot be doubted, but they have only mitigated the evil, and so long as the balanced compound locomotive is used, motive power departments will have to deal with the problem of keeping the high pressure crank pins round enough to run cool and without pounding.

Fig. 3 is a sketch of the crank axle of an Atlantic type passenger engine, and shows the extent to which the inside crank pins very often become worn out of round. The crank pin is nearly always worn most on the quarter of its circumference nearest the center of the axle. In this case the left hand crank is worn away 3/16 in. at this point, while scarcely any wear at all can be detected on the opposite side of the pin. It is obvious that a workman, who was set to work to true up this pin with a file, would naturally do so by removing the smallest possible amount of metal, but by so doing he would increase the distance between the center of the crank pin and the center of the axle nearly ⅛ in. This would mean an increase of ¼ in. in the stroke of the engine. A little carelessness might also result in the crank pin being trued up at an incorrect quarter, with respect to the other cranks. Hence, the problem is not only one of making the crank pin round, but involves its restoration to the original throw and quarter.

Until recently a file was about the only tool on the market in America which could be used for this work. Several re-turning devices have been exploited at different times with more or less success. Figs. 4 and 5 show how the railways of Europe have been meeting the difficulty. The re-turning machine (Fig. 4) is a French production, which may be applied to an ordinary wheel lathe, the crank axle being supported by the centers of the lathe. The machine consists of a two piece, annular gear, which is made to revolve within an outer case, which is also made in two pieces. The cutting tools are carried by the two cross bars which are hinged at one end to the inside of the gear; the other end is fastened to the gear by means of an adjustable screw arrangement, which also provides a radial feed for the cutters. The power is applied by means of a belt passing over a pulley; a train of gears transmits the motion to the large annular gear. A set of auxiliary gears is provided which can be made to slide the upper part of the machine along dove-tailed ways on top of the base casting, thus effecting an axial feed. This is, no doubt,



A POWERFUL EUROPEAN CRANK AXLE RE-TURNING MACHINE.

a powerful machine, but it has the disadvantage of being a stationary shop fixture, making it necessary to remove an axle from the engine in order to re-turn the crank pins.

The betterment department of the Santa Fé Railway has recently designed a portable crank axle re-turning machine which has proven very satisfactory, several of these machines being in successful operation in different shops on the Santa Fé System (Figs. 6, 7 and 8). This device weighs about three hundred pounds, and may be driven by any large air motor. It is so compact that it may be used on an inside, or high pressure crank pin, while the crank axle remains under the engine (Fig. 7). The only preliminary work required is the removal of the back end rod strap and brasses, and the shifting of the crosshead to the forward end of the stroke, in order that the connecting rod will be out of the way. This feature, in connection with the air motor drive (motor may be seen over top of crank axle in Fig. 7), makes it an extremely valuable tool in the roundhouse.

This device consists, as shown in Fig. 8, of a two-piece annular worm gear enclosed in the outer case, much the same as an eccentric is enclosed in the eccentric strap. This gear carries two high speed steel cutters, which are situated diametrically opposite each other, and are set in an inclined position so as to provide top rake. One end of these cutters is shaped to fit the fillet at the ends of the crank pin bearing, while the other end is backed off for clearance. Both cutters begin their cuts at the middle of the crank pin (the two cuts overlapping about ¼ in. at the middle) and are fed outward toward the fillets. Each of the tools may be fed either axially or radially to the crank pin. Both the axial and radial feeds may be operated automatically, by means of the star wheels, which as they revolve around the crank pin, engage specially shaped feeding pins. Any one of the feeds may be operated separately, or all may be used at the same time.

Fig. 6 shows the manner in which the feed pins engage the smaller star wheels which drive the axial feed screws. An ingenious centering device (indicated by the arrows, Fig. 7) makes it possible to adjust the machine to turn cranks of either 26 or 28 in. stroke.

To turn a crank pin with this machine the axle centers should first be accurately located on the inner surface of the cheeks, provided of course, that these centers are not already marked, as is always the case with the built up axle. A line should also be struck through the center of the crank pin and the center of the axle. The position of this line should be marked by a prick punch on the edge of the cheek, as indicated by the letter "Y" in Fig. 3. These points when once located, can be used for all subsequent re-turnings.

In setting up the machine the lower half is placed in position first, and is held in place by inserting the points of the large set screws of the centering device (indicated by the arrows, Fig. 7) into the axle center. The points of these screws must be previously adjusted to the distance from the center of the gear which corresponds with the throw of the crank, which insures the crank being restored to its proper throw. Next, the whole machine is assembled around the crank pin and bolted securely together. A small mark on the worm housing, on the upper half of the case, indicates the position of a line passing through the center of the gear and the center of the large screws of the

FIG. 6.—PORTABLE RE-TURNING MACHINE FOR INSIDE CRANKS.

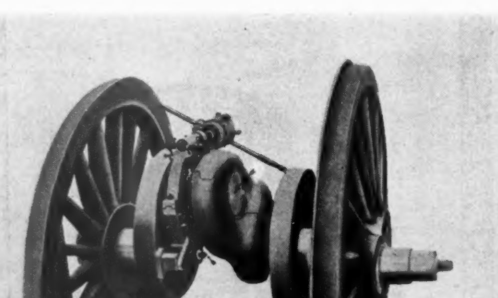


FIG. 7.—PORTABLE MACHINE AT WORK. AIR MOTOR DRIVE.

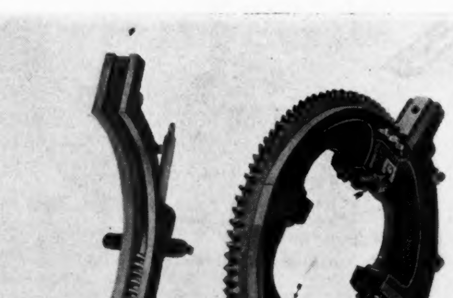


FIG. 8.—PORTABLE MACHINE WITH HALF OF CASE REMOVED.

centering device on the lower half of the case. The whole machine is shifted until this mark is exactly opposite the prick punch mark previously located on the corner of the disc, and is clamped there by means of pointed set screws located at convenient distances on the periphery of the case. This step takes care of the quartering of the axle. The sides of the gear are machined parallel to the plane of rotation, and hence offer a means of lining up the machine so that the pin will be turned perpendicular to the cheeks. A crank axle which has seen enough hard service to necessitate the re-turning of its high pressure crank pins is usually sprung more or less, hence the machine should always be lined up parallel to the cheek next to the driving box bearing, since this cheek is less likely to be sprung out of position.

The device is now ready to operate, and if due care has been exercised in the setting, the crank pin will not only be turned round and true, but it will be restored to its original stroke and quarter as well.

In the matter of cost of work done, this machine holds a decided advantage over any other method in use. It is possible to reduce the diameter of an eleven inch crank pin 5/16 in. in six hours. This includes all the time used in setting up the machine, carrying tools to and from the tool room, and all preliminary operations except the locating of axle center. However, there are a great many little things which could happen to delay the job, and which may increase the total time to eight hours. The operator should be a good machinist, and he will need the assistance of a helper or laborer for about two hours, when setting up the machine. About one hour's filing with a fine cut file is usually required after turning in order to put the pin in first-class condition.

The following figures show the saving over hand filing, which is made possible by the use of this device:

The first cost of the machine is about	$550.00
Cost of air motor of sufficient size to operate the machine	100.00
Total	$650.00
Machine charge, 10c. per hour for six hours	$0.60
Operator's wages at 34c. per hour, six hours	2.04
Helper's wages at 17c. per hour, two hours	0.34
One hour's filing	0.34
Total cost turning and filing one crank pin	$3.32

One man could probably do the same amount of work with a file in about three days, or thirty hours. Thirty hours filing at 34 cents per hour would cost $10.20. To do this job by hand under an engine is hard and tedious work, and it is impossible to get the pin perfectly true, besides there are other disadvantages.

Comparing the two methods we have:

Cost of filing one crank pin	$10.20
Cost of turning and filing one crank pin	3.32
Saving effected by use of machine	$6.88
Per cent. saving	69

The first operation connected with truing up an inside crank pin in a stationary machine, is to remove the crank axle and wheels from the engine. To remove a pair of main drivers from a balanced compound locomotive, and replace them again with the drop pit arrangement, used in most roundhouses, requires the services of a machinist and his helper for about 18 hours and the assistance of an additional helper is needed for about 8 hours. A fair estimate of the total cost of a drop pit jack equipment would be $500, and 30 per cent. per annum is a common rate of surcharge for such equipment. On this basis, the hourly rate of surcharge would be 5 cents.

The following figures illustrate the cost of removing a pair of drivers with crank axle from a locomotive and replacing them again after having been turned and trued up. For the sake of conservatism the surcharge rates given in connection with the operation of the stationary machine are much lower than it is good practice to place them, while the rate given for the portable machine is based on the actual surcharge placed upon it:

Wages of machinist at 34c. per hr. for 18 hrs	$6.12
" " helper " 17c. per hr. for 18 hrs	3.06
" " " " 17c. per hr. for 8 hrs	1.36
Total labor cost of removing and replacing axle	$10.54
Drop pit jack charge at 5c. per hr. for 18 hrs	.90
Total cost of removing and replacing axle	$11.44

To deliver the axle and its wheels from the drop pit to the machine will in most cases require the services of 6 laborers for a half hour and the same time to return the axle and wheels from the machine to the drop pit—wages, 6 laborers at 15 cents per hour for 1 hour, $0.90.

Assuming that an inside crank pin can be trued up in four hours time, and that the cost of the machine is $1,100, 20 per cent. of which value is charged annually to cover machine charges, supervision, etc., constituting the "surcharge," the actual cost of re-turning one inside crank pin would be as follows:

Machine charge at 7c. per hour for 4 hours	$0.28
Operator's wages at 34c. per hour for 4 hours	1.64
Operator's helper's wages at 17c. per hour for 1 hour	.17
Cost of re-turning one crank pin	$2.09

Summing up the foregoing we have:

Cost of removing and replacing axle in engine	$11.44
Cost of handling axle between drop pit and machine	.90
Cost of turning crank pin	2.09
Minimum total cost of turning up one crank pin on stationary machine	$14.43
Total cost of turning up one crank pin on portable machine	3.32
Difference in favor of portable machine	$11.11
Per cent. saving	79

The above figures indicate only the possible saving on the cost of the work. It often happens that an engine is held in the roundhouse solely on account of work on the high pressure crank pins. In such a case the saving effected by the machine, over hand work, would be increased by the amount the engine would earn during the time saved by the machine, and this would amount to from $4 to $10 per hour of detention from earning service.

Another saving which is effected by the use of this machine, and by far the largest, is the cost of delays to traffic, due to engine failures and damage to equipment which might be prevented to a considerable extent if some rapid and accurate means of truing up high pressure crank pins were provided in the roundhouse. The balanced compound locomotive has achieved a great success abroad because it is one of the fastest, most powerful, most economical, and at the same time easiest on road bed and track, of any type of engine. American railroad men have looked rather askant at the complication involved in this type of construction, and they have foreseen the troubles that would be incident to the use of crank axles. Now that a device has been perfected for correcting, and to a large extent overcoming and eliminating these troubles, the problem of the crank axle, from a mechanical and operative point of view, may be said to be solved for American railroad practice, thus enabling railroad managers to take advantage of this type of high speed and high power motive equipment.

The machine here described is in use at a number of the shops and roundhouses on the Santa Fé, and is being manufactured by The Tool & Railway Specialty Manufacturing Company of Atchison, Kansas.

Fuel Economy.—In speaking before a meeting of the American Society of Mechanical Engineers, on the conservation of the nation's fuel supply, Dr. W. F. M. Goss showed that the necessary steps to secure economy of coal were:

a. Scientific research for the establishment of facts.

b. Practical development of the facts thus developed on a scale which will convince men that there is profit, direct and indirect, in a better practice.

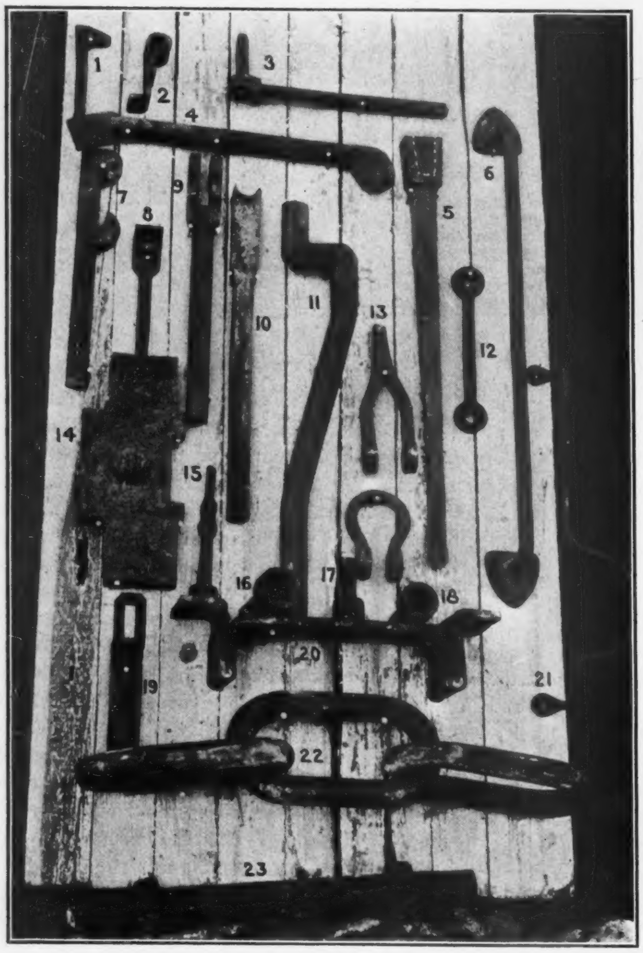
c. Restrictive legislation which will protect the public from the competition of unscrupulous men.

d. Effective inspection which will secure enforcement of laws. The process must begin with education—not with coercion.

FORGING AT THE GREAT NORTHERN RAILWAY SHOPS.*

In the Great Northern Railway shops, St. Paul, Minn., are three forging machines, one 4-in. Ajax, one 2½-in. Blakeslee and one 1½-in. Ajax. In addition there are two bolt heading machines, a 1¼-in. Ajax and a small Blakeslee machine. A few of the articles which are made in these machines—selected for their novelty and clean-cut finish—are shown in one of the illustrations. All of these pieces come from the machine just as they are shown, with the exception of No. 5, the handle of which is drawn out after the socket is made on the machine. The method of making these parts is briefly described as follows:

No. 1 is a hook bolt made from ¾-in. round stock. About 6 in. at the end of the bar is first upset to ¾ in. square. It is then reheated and upset, as shown.



EXAMPLES OF MACHINE FORGINGS MADE AT THE GREAT NORTHERN SHOPS.

No. 2, a car apron hinge, is made in one heat with two movements.

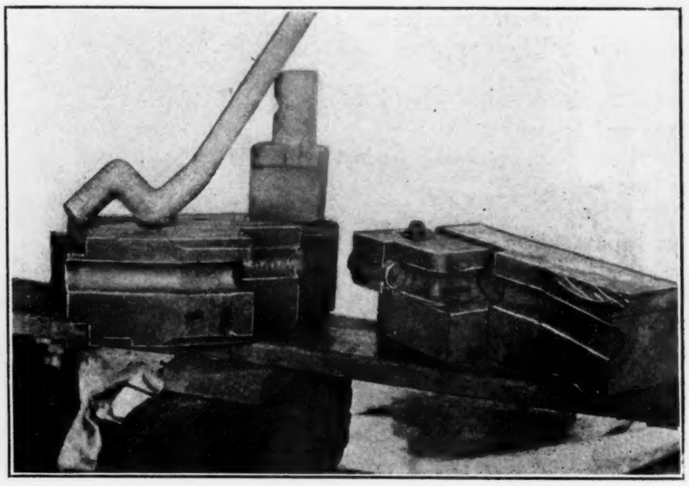
No. 3, a gate hinge, is made from 1-in. stock in two heats with three movements.

No. 4, a pilot brace, is made from 1½-in. stock in one heat and two movements for each end.

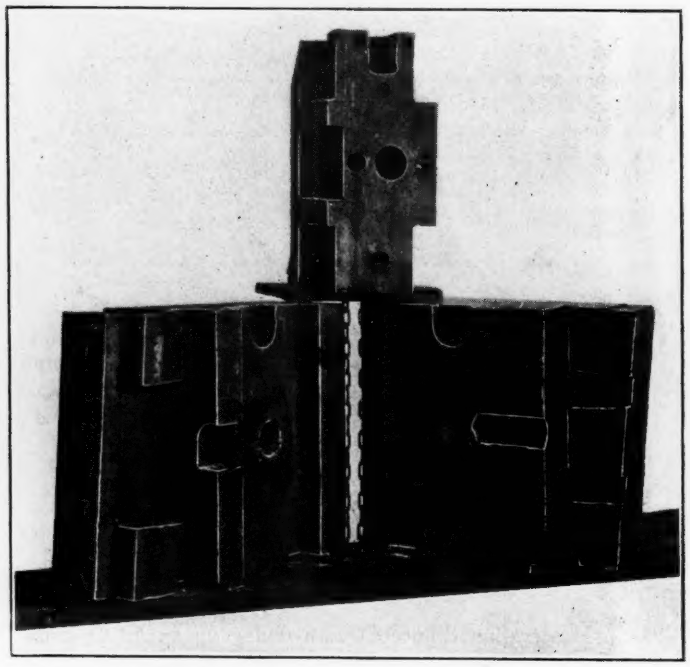
No. 5, grate shaker lever, is made from 1 x 2-in. stock; the socket end is made in one heat and two movements. The end is first upset and the socket is then formed. The handle is drawn out under a steam hammer.

No. 6 is a tank hand-hold, each end of which is made in one heat and two movements.

No. 7 is a tie bar made from 1½-in. round stock. The inner lug is first upset in the lower die, after which the bar is reheated and the end lug is formed in the upper die. The slot is then punched to suit the size of the rail, by a side movement of the machine. This method is much more satisfactory than that of having the operator step on top of the machine and hold the bar in a vertical position while the slot is punched by the header. Forty thousand of these bars were made last year, at the rate of 250 complete bars per day of ten hours. During that time no repairs were made to either the dies or punch. The dies and punch are cooled by a stream of water which runs constantly while the machine is in operation.



DIES AND FORMER FOR NO. 11.



DIES FOR MAKING NO. 14.

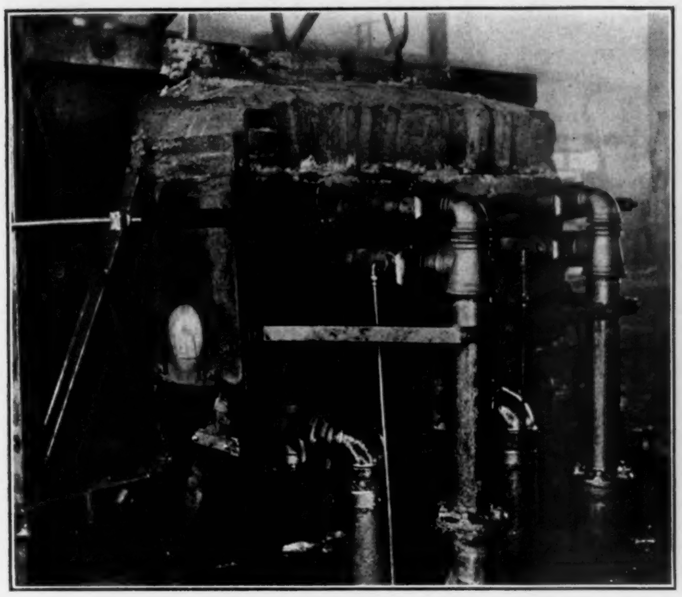
No. 8 is a brake beam guide pin made from 1½ x 2½-in. stock. The shank is drawn in the first heat and the gib is bent and a hole punched in one movement in the second heat.

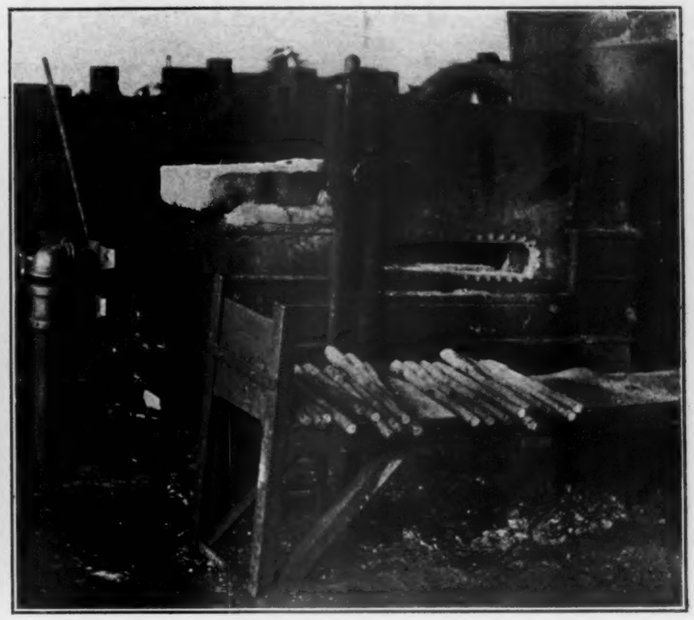
Nos. 9 and 10 show the jaw and strap ends of switch connection rods which are made from 1½-in. round stock.

No. 11 is a switch stand crank which is made from 1⅞-in. round stock in one heat and two movements. The dies for making this piece are shown in one of the illustrations and consist of three pieces. A sliding block is attached to the side of one of the dies. The two dies closing together sidewise bend the stock and the header striking the sliding block completes the piece.

No. 12 is a clevis. It is made from round stock, each

* Articles describing the machine forging work done at the Collinwood shops of the Lake Shore & Michigan Southern Railway may be found on page 142 of the April, 1906, issue: page 234, June, 1906; page 192, May, 1907, and page 344, September, 1907. Similar work which is being done at the South Louisville shops of the Louisville & Nashville Railroad was described on page 125 of the April, 1907, issue. Examples of work done by forging machines and bulldozers at the Topeka shops of the Santa Fe were illustrated on page 463 of the December, 1906, issue.





APPLICATION OF SPECIAL CRUDE OIL BURNER TO LARGE AND SMALL FURNACES.

end requiring one heat and two movements. The first movement upsets the end into a round disk, the second punches the hole. After the two ends are prepared in this way the piece is bent on a small bulldozer to the shape shown just below No. 13 and just above Nos. 17 and 18 in the illustration.

No. 13 is a brake hanger. The ends are made in the same way as those of the clevis, from ¾ x 1-in. stock. After the eyes are formed two pieces are welded together on the machine; they are then spread apart to the required width.

No. 14, a follower plate, is forged from 1½ x 7-in. material. The dies for making these plates are shown in one of the photos. One movement of the machine shears the plate to size and the second movement forms the boss. It will be seen that those parts of the dies which shear the plate to shape have the cutting edges tapered at opposite angles, thus reducing the strain on the machine to a minimum, while they are shearing the piece.

Nos. 15, 16, 17 and 18 show different size socket wrenches. These are made in all sizes, with either hexagon or square heads, in one heat and two movements. They are said to be made more quickly than the ordinary engine bolt.

No. 19, a car door hasp, is made in one heat and two movements.

No. 20, a carrier iron, is made from ⅝ x 5-in. stock in one heat and three movements.

No. 21 is a grab iron which is made from ⅝-in. round stock. One heat and two movements are required for each end. The end is upset in the first movement and the hole punched in the second. The bend is formed by a side motion of the dies.

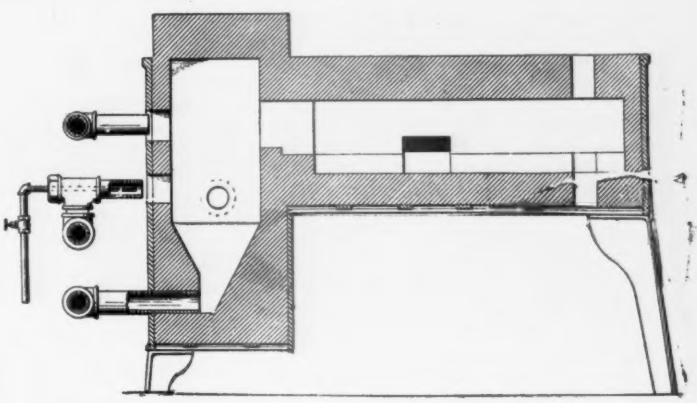
No. 22 is a three-link coupler for wrecking outfits. It is made from 1½-in. stock and is bent and welded on the machine.

No. 23, a brake fulcrum, is made in one heat.

The larger pieces, such as the switch stand crank, the follower plates and the shaker lever, are made on the 4-in. machine. The smaller parts are made on the 2½ and 1½-in. machines.

The rate at which the work can be turned out on these forging machines is of course limited largely by the rate at which the furnaces can heat the material. A special arrangement of burners is used in the furnaces in this shop, which has been patented by Mr. Yoerg, the shop superintendent, and Mr. Treacy, the master blacksmith. These burners not only furnish perfect combustion, thus heating the material in a shorter time and with a minimum amount of oil, but will do this with the cheapest and dirtiest crude oil on the market, costing from three to three and a half cents per gallon. This is accomplished by using a triple blast, as shown on the drawing. The oil is sprayed under pressure through the central burner and strikes the opposite wall of the combustion chamber, separating it into fine particles. These are ignited and the blast from below mixes with them, thus assisting the processes of combustion, and carries them to the upper part of the chamber. Here they meet the upper blast which insures complete combustion and forces a clear white flame of intense heat on the material in the heating chamber.

The pipes are all outside the combustion chamber, and are readily accessible for cleaning or repairs. They are said, however, to require practically no attention or expense for these items. No carbon formation at all can be found in the furnaces in this shop. The third or top blast may be made to



YOERG-TREACY BLAST ARRANGEMENT FOR CRUDE OIL FURNACE.

drive the flame a long distance, thus making it possible to heat material of such length that two ordinary burners would be required. The photographs show the blast pipes in detail as attached to one of the larger furnaces, requiring two sets of burners; also a similar arrangement applied to one of the smaller furnaces. Fourteen of these furnaces are in operation in the shop, also several portable rivet heating furnaces.

We are indebted for information to H. Yoerg, shop superintendent, and J. Treacy, master blacksmith.

OUR FUEL SUPPLY.—All estimates of future consumption and destruction of coal are liable to error, yet making all reasonable allowance, unless there be careful husbanding, or revolutionizing inventions, or some industrial revolution comes which cannot now be foreseen, the greater part of that estimated 2,500,000,000,000 tons of coal forming our original heritage will be gone before the end of the next century, say 200 years hence.—*Andrew Carnegie at the Governors' Conference.*

UNIVERSAL STANDARD FREIGHT CARS

Millions of dollars worth of surplus material is being carried at the freight car repair points because of the lack of universal standardization. A few months ago, during the scarcity of freight cars, thousands of them were held out of service on foreign lines for considerable periods because of the necessity of securing material from the home road for making proper repairs.

The American Railway Association and the Master Car Builders' Association have done splendid work in the way of standardization, but they have hardly more than started this work. Much remains to be done.

The following letter was recently sent to a number of leading railway officials: "Would it not be desirable for the American Railway Association to advise the Master Car Builders' Association to design, in detail, a series of standard freight cars, of such types and capacities as are best suited for different conditions of service? The general adoption of such cars would facilitate the making of repairs, increase the efficiency of the cars and reduce the expense of maintenance. Is there any important reason why this should not be done?"

Extracts from some of the replies to this letter are as follows:

Union Pacific System—Southern Pacific Company.

I do not know of any reason whatever why standard freight cars, of types and capacities suited to different conditions of service, should not be adopted by the American roads. There are many very strong reasons why standards should be adopted. Such practice would facilitate the making of repairs and would reduce largely the amount of idle capital tied up in repair parts accumulated at junction points, would increase the efficiency of cars largely by reducing the time that they are in shops, and would reduce the actual cost, as the parts could be kept in stock by car builders, instead of having to let contracts for castings, forgings, etc., after receipt of orders.

The adoption of a standard car, moreover, would facilitate the formation of a freight car pool, to which I believe we shall ultimately be driven by interchange conditions.

The Master Car Builders have been able to agree on but a limited number of standards, and *I am strongly of the opinion that the initiative in this matter should be taken by the executive heads of some ten or twelve large systems. If these gentlemen should issue positive instructions to their car builders to agree on standards, and should then adopt them, the problem would be solved.*

J. Kruttschnitt,
Director of Maintenance and Operation.

Canadian Pacific Railway Co.

I do not believe any practical advantage would be gained by the Master Car Builders' Association designing a series of standard cars. It is true that several large systems have determined on standards applicable to all roads under their control, which is to a certain extent an indication that there is no need for the large variety of cars that they have been constructing, but on the other hand this same action has established a number of different standards which it would be impracticable to revise and unite into one on all the roads for many years to come.

I consider that the good of the railways is better served by the Master Car Builders' Association steadily developing certain standards of details which it is practicable to adopt throughout the country. They have done a large amount of work in this way and no doubt will be able to do more. Draft gear attachments and hand brake rigging no doubt could be better standardized than they are. I see no reason why certain standard trucks of various capacities, having several heights for each size of truck, should not be designed, and with some prospect of their final adoption; but the designing of an entire car and calling it the Master Car Builders' standard would mean in all probability such a standard being neglected until one line after another had introduced improvements which would cause them to prefer their own design to that of the Master Car Builders' Association.

I am doubtful also whether even at present the design of a steel car is sufficiently determined to enable a final standard to be arrived at, and the whole course of things is opposed to all roads converging on one design. Different roads start out with different ideas and gradually develop these until they are in a more or less perfect state, and during this time they have constructed large numbers of cars, as a rule along more or less uniform lines of construction, but each road working along a rather different system to obtain final results.

The ultimate result is a number of varying designs each of which has been brought to a state of practical perfection. I do not believe this method of evolution can be arrested or modified by any action of the Master Car Builders' Association.

H. H. Vaughan, Asst. to the Vice-Pres.

The Atchison, Topeka and Santa Fe System.

Undoubtedly it would be beneficial if all of the cars in the United States were constructed according to a common standard. It would also be beneficial if an agreement with respect to future standards of construction could be reached, but I do not believe it is possible.

The American Railway Association some time ago considered this matter very fully and decided upon certain standards of length, breadth, and height of box car bodies, which they recommended. I have never adopted these recommendations, because I believe that the width and height of box cars should be the maximum that clearance permits, and that the length should be regulated by the character of the traffic carried. Then there is a great diversity of opinion as regards carrying capacity, there being advocates of 60,000, 80,000 and 100,000 pounds. I believe in a capacity of 70,000. If an 80,000 pound car is built, the percentage of dead weight will be practically the same as that of a 100,000 pound car, the difference in weight being, say, 4,000 pounds. There should not be more than 400 pounds difference between a 60,000 and 70,000 pound car. Cars of 100,000 pounds capacity are not economical for use on western roads, or in sections of the country where heavy loading is not the rule. For instance, the average loading of our cars, we will say, is 20 tons. I can see no use, in fact it is very uneconomical, to haul 3,600 pounds additional dead weight for the sake of having this extra capacity, which can seldom be utilized. To attempt to standardize the equipment of the United States along the lines suggested by you is, I fear, impracticable. I know of no one else who has built any 70,000 pound cars, yet we would not care to depart from the standards adopted, and I suppose every manager in the country entertains similar views about the type of car he is building.

Moreover, there is a great diversity of opinion about underframing. Some believe in the steel underframe, some do not. At present I am inclined to favor a composite underframe, reinforcing the center sills with channels, between which the draft rigging can be inserted, fastening them to the wooden sills by bolts and tying the whole construction together with truss rods which extend through cast plates, which cover the wooden end sills. The wooden superstructure of the center sills, or the upper member, prevents corrosion of the lower member by protecting it from drippings from sulphurous coal, etc. In case cars are wrecked center sills rarely sustain any damage, whereas, the steel side sills are almost always very badly distorted. Again, there is a difference of opinion as to whether steel sills should be of pressed, or built of structural material. I favor the latter construction.

After long and tedious argument the result would probably be some further inoperative recommendation as to general dimensions. I do not think that the plan you suggest is at all practicable.

J. W. Kendrick, Second Vice-Pres.

The American Railway Association.

While I think the suggestion is undoubtedly a good one, I am very apprehensive as to whether it would be possible to accomplish anything in that direction under existing conditions.

As you are aware, the Master Car Builders' Association has been endeavoring for several years to secure a standard design for a drawbar coupler, in order to obviate the necessity for carrying in stock a large number of different parts for the purpose of making repairs to foreign cars.

While this is gradually being brought about, it will probably be some years before any considerable improvement is made in that direction; and, in the meantime, I do not think it will be feasible to do anything in the way of adopting a standard car, such as you suggest.

W. C. Brown, President.

GREAT NORTHERN RAILWAY COMPANY.

There is such a difference in the traffic handled in different localities that a car which will suit one place will not suit another. Custom has also a great deal to do with the pattern and size of cars.

JAMES J. HILL, Chairman of the Board.

THE BALTIMORE & OHIO RAILROAD COMPANY.

We are of the opinion that nothing would be gained by establishing standards for all details of freight cars. A great deal has already been accomplished by the Master Car Builders' Association, in the direction of standardizing the parts of cars which are liable to become defective while the car is away from home; the object being that each railroad may carry a stock of standard parts. Much has also been done by this Association in the design and location of safety appliances, and these standards are in very general use by the railroads of the country.

The American Railway Association has established exact dimensions for box cars. These dimensions have not been adopted by all railroads, as the commodities handled in different parts of the country require changes in the dimensions to suit the local conditions.

It is our opinion that as much latitude as possible should be given for improvement in design of all details in connection with railroad construction. Through independent thought and the free use of individual designs and methods, we believe the present high standards have been largely obtained.

OSCAR G. MURRAY, President.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY CO.

So far as the cost and maintenance of car repairs is concerned a uniform car would do much to relieve the situation. However, we feel that the traffic conditions of the different roads necessarily largely determine the class of cars that would be most economical in its service; for example, cars used largely for handling lumber and grain should be of a larger cubic capacity than cars used on roads that handle a large proportion of mineral products.

So far as steel construction is concerned it is yet far from perfect and a standard car, if made standard in its general construction, would naturally have the effect of stopping progress or improvement in steel construction. We have not yet, in my opinion, reached a condition where this is warranted; more than this, I do not think it would be possible for all the roads to realize equal benefits from the same type of car.

W. J. UNDERWOOD, General Manager.

THE DELAWARE AND HUDSON COMPANY.

It is hardly possible that one box car, one type of coal car, or one kind of flat car can be adopted and used universally. Cars owned by any railroad put in the greater part of their time upon the rails of that railroad and in handling its peculiar type of tonnage, and therefore its cars are designed with a view of getting the most economical results from handling this peculiar kind of business. We find in following this a little farther that for the merchandise shipments of New England, the New England roads will generally build smaller box cars and of less capacity than the grain carrying roads of the West, and that the railroads carrying coal to the South will build a coal car which will return lumber to the North.

In other words, the New England road will build a box car for handling merchandise and the Western road for handling grain, while a road with large furniture or agriculture implement establishments will build a larger box car as to cubical contents, than the grain carrying road, but of less capacity in tons.

I therefore feel that it is proper to always have a considerable diversity in the types of cars.

C. S. SIMS, Second Vice-Pres. and Gen. Man.

THE LONG ISLAND RAILROAD COMPANY.

We are of the opinion that it would be desirable for the American Railway Association, in conjunction with the Master Car Builders' Association, to design standard freight cars of such types and capacities as are best suited for different conditions of service. We think the first move would be to have the car committee of the American Railway Association report to the Association before the question is taken up with the Master Car Builders' Association.

RALPH PETERS, Pres. and Gen. Man.

CHICAGO, BURLINGTON & QUINCY RAILROAD COMPANY.

I do not consider that such work on the part of the Master Car Builders' Association would be desirable. It would be simply like asking a convention of tailors to furnish specifications for a suit of clothes for the average man, and we know, of course, that there is no such thing as an average man. Neither are the freight car requirements the same on different railroads in the United States. It is true that many of the details entering into the construction of freight cars are the same, and are standard to-day on the great majority of the American roads; and so far as it is possible to standardize details which are common, I think such action should be taken and I believe it is being taken at the present time, but I am quite sure, speaking for this company, that we would not feel disposed to accept as our standard car a car which might be designed by a committee of very eminent mechanical men, but without special reference to our service requirements.

D. WILLARD, Second Vice-President.

ST. LOUIS AND SAN FRANCISCO RAILROAD COMPANY.

As all the large systems of the country are endeavoring to adopt standard equipment, I believe that the general adoption by the M. C. B. Association of standard freight cars would be simply an additional step forward.

Freight traffic is shipped in carload lots from one end of the country to the other, and in the event that one standard for each class of freight cars could be adopted, it would reduce the cost of repairs of home cars on foreign lines, and as you state, increase their efficiency.

There is certainly no important reason why the Master Car Builders' Association should not design standard freight equipment; on the contrary, there are good reasons why it should be done.

A. DOUGLAS, Fourth Vice-Pres. and Gen. Aud.

THE CHICAGO, ROCK ISLAND & PACIFIC RAILWAY CO.

I agree that it is desirable, but up to the present time it has not been possible to secure the co-operation of the principal roads.

Several years ago the American Railway Association decided on 38 ft. as the desirable standard for the length of box cars; also on standard width and height, but only a few of the roads accepted this standard and they have gone their several ways in the construction of cars of different sizes.

There could certainly be no objection to having the Master Car Builders agree on a design for cars of different types, with the hope that their recommendation might become standard on a large number of roads.

H. U. MUDGE, Second Vice-President.

ATLANTIC COAST LINE RAILROAD COMPANY.

It would, of course, be a matter of great convenience, and would facilitate the making of repairs, if all cars of each class were alike, but the requirements are so varied, and the ideas of mechanical officers so different as to the best type and design of car, that I am afraid it would be a very difficult task to arrive at a standard car.

W. N. ROYALL, General Manager.

——— RAILROAD.

The fact that the box car committee of the American Railway Association has had wide experience in working upon a similar problem makes it important that the advice of that committee should be secured before entering into the broader investigation proposed.

The features that would have to be covered by such a recommendation are many, and involve important operating and traffic conditions as well as the question of designs. It would, therefore, seem advisable, if it is decided to make such an investigation, to have it placed in the hands of the box car committee to report to the Association upon the general dimensions and capacities of the different types of cars, after which the Master Car Builders' Association could be asked to recommend the prominent details of construction adapted to such dimensions and capacities. Such an investigation, if carefully worked out to a conclusion, would be one of great magnitude, as is evidenced by the fact that the box car committee, which was appointed in 1899, spent more than two years in working up its report upon box cars alone.

——— ———, General Manager.